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A
BIBLIOGRAPHICAL MONOGRAPH
ON
PLANT GENETICS
(GENIC ANALYSIS)

1900 - 1925

By

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FOREWORD

With the rediscovery of Mendel's laws in the year 1900 opened a new era in the development of the science of heredity and variation, and there is nothing in the history of biology comparable to the rapidity with which the new principle has spread and the enormous influence it exerted on other principles of biology, other than the case witnessed in the years following 1859 on the appearance of Darwin's 'Origin of species by means of natural selection.' In these respects Mendelism and Darwinism show a singular coincidence. Mivart, in speaking of Darwin's work, writes in 1871: "Remarkable is the rapidity with which an interest in the question of specific origination has spread..... Indeed there are few drawing-rooms where it is not the subject of occasional discussion, etc." Almost the same thing may be said with regard to the great sensation created by the rediscovery of Mendel's principles. Bateson, in referring to the sudden discovery of Mendel's long-forgotten work, states in 1902: "It was a moment of rejoicing, and they who had heard the news hastened to spread them and take the instant way." Also an American botanist said some years ago in a popular lecture that Mendelism was an evil disease, so many biologists who approached having immediately caught it. Again A. Kerner writes in 1869: "Kein Werk hat in neuerer Zeit einen so mächtigen und tiefgreifenden Einfluss auf die Entwicklung der naturhistorischen Forschung ausgeübt wie Darwins Buch über die Entstehung der Arten. Wie ein Ferment wirkt die Theorie, welche von dem englischen Forscher entwickelt wurde, fort und fort, eine Gährung auf dem Felde aller naturgeschichtlichen Disziplinen veranlassend, wie die Geschichte der Naturforschung keine ähnliche zu verzeichnen weiss.—.....Vielmehr mehrt sich von Tag zu Tag die Zahl neuer Quellen und Zuflüsse und immer mächtiger und wuchtiger fluthet der Strom in seinem neuen Bette dahin." This applies exactly to the case of Mendel's principles.

To ascertain the rapid development of Mendelian analysis or gene-analysis in plants since 1900, we will examine some numerical

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data, so far as the present book by Mr. Matsuura supplies them. We find that in the first eleven years (1900–1910) there appeared 151 papers by 61 authors, in the next decade (1911–1920) 604 papers by 268 authors, among whom 234 were new authors, and in the following 5 years (1921–1925) 581 papers by 317 authors, among whom 217 new, this making a sum total of 1336 papers by about 512 different authors during 26 years. These numbers of investigators and their reports, which may serve more or less as a measure of activity and progress in the new branch of biology, may seem at first not so large as might be expected; but when we consider that a Mendelian analysis usually requires a few years at least before we get any conclusive result, we shall realise how rapidly the new principle has spread, and how actively it was followed up during the first quarter of this century.

It may be noted *en passant* that there is a markedly abrupt rise in frequency curves for the numbers of authors and their reports in 1911 and 1921, that is to say, periodically at the beginning of each new decade, probably as the result of an accumulation of important data, which is partly indicated by the appearance of comprehensive reference works toward the end of each decade. The latter will in turn make it easier for one to get a better orientation, and give suggestions for further investigations, and this together with several new discoveries in each decade, stimulated the periodical rise of activity in new researches.

The results of the discovery of Mendel's laws were prodigious. The science of heredity was at once raised to the rank of an exact science; characters were analyzed, and units, elements, or quanta in heredity, viz. genes were established as entities essential to the development of individual characters. So it has been said that Mendel's experiments are worthy to rank with those which laid the foundation of the atomic theory in chemistry. Among other things the influence exerted on Darwinian theory by the discovery of Mendel's principles has been very great and even led Bateson to declare: "Had Mendel's work come into the hands of Darwin, it is not too much to say that the history of the development of evolutionary philosophy would have been very different from that which we have witnessed."

Important indeed is the discovery or promulgation of laws in science and they are useful tools for further operation in scientific works; yet the problem remains only half-solved until we know how the laws come to exist. It is the internal processes in the body of the organism and the relation between organisms and their environment, which dictates the laws in biology; in other words biological laws are

the logical expressions of organic processes in generalized terms. From this point of view the explanation of the underlying process itself is no less important than the enunciation of a law.

In the history of physical science, it is, however, generally the case that laws are promulgated first, while the explanation of, how the natural processes involved proceed just as is enunciated in the law becomes possible as a rule a long time afterwards. Mendel's laws too were founded without any factual details of cellular processes involved in the laws being known at his time. It was, however, only a few years after the rediscovery of the laws, that the behaviour of chromosomes in the meiotic division was cited for explanation, and Mendel's far-sighted postulates that the union of differential heredity 'elements' from both parents is temporary, being retained only through the vegetative life of the hybrid, and that they are set free at the formation of sexual cells, whereby re-groupings of all the existing elements taking place by way of random-assortment with one qualification that the differential elements (allelotenes) exclude each other, were fully confirmed in their every detail, *mutatis mutandis* in view of linkage phenomena.

As a consequence, it became evident that the unity of natural processes underlies the phenomena of inheritance in hybrids and normal organisms in general, for the chromosome behaviour in the meiotic phase is generally the same in both cases. Also the fact that both the normal and abnormal characters, which are essentially not different, the only chief difference being in the frequency of their occurrence, actually follow the same laws in their inheritance, was ascertained in a large number of cases; and it was by these abnormal characters that many fruitful experiments in genetics were borne out; e.g. the establishment of several hundreds of genes in *Drosophila melanogaster* and more than two hundreds in *Antirrhinum majus*. Moreover latest investigations showed that not only strain and varietal hybrids but also species hybrids follow Mendel's principles, although it must be understood here that this can be the case only where the formation of gemini by allelochromosomes takes place regularly. Thus we are probably justified to consider strain, varietal and specific characters, and presumably generic characters too, under one category. Considering these points, facts and principles of genetics, conjointly with those of cytology, seem to be supplying materials for laying a sounder basis to the future principles of taxonomy than we have hitherto had.

Post-Mendelian laws, the 'law of the number of linkage groups' and the 'law of linear relations in the arrangement of genes,' both of

which were brought to light by the achievement of Morgan and his co-workers, have also added greatly to our knowledge for the understanding of the phenomena of heredity and variation. The former is the logical consequence, when we admit that, 1) chromosome is the bearer of the heredity units, 2) individuality of chromosomes is largely retained, and 3) that the number of chromosomes in a nucleus is generally definite in each species or form; and the law is beautifully supported by experimental data in the case of *Drosophila* and also by the data at hand in *Zea*, and awaiting further endorsement by other examples. The latter law has been derived by deduction from the numerical data obtained by a sufficient number of experiments in *Drosophila*, and, it being also supported in plants by the cases of *Pisum* and *Zea*, further verification is expected.

As to the physical basis of the linear arrangement of genes, chromomeres which certainly show the linear arrangement, have often, since Roux's argument in 1883 on the linear arrangement of 'qualities,' been alluded to as heredity-unit bodies; but this idea has as often been abandoned for the reason that the total number of chromomeres in a nucleus is not sufficient to account for an innumerable number of characters in a higher organism, evidently owing, however, to an erroneous conception of older particulate theory. The present particulate theory in genetics stands on the similar footing as the atomic theory in chemistry, and it is sufficient to remember that an enormous numbers of all known chemical substances are products of reactions between some ninety different chemical elements only. I also objected in 1920 to the chromomere hypothesis on a different grounds, that the number of chromomeres varies according to the different stages in the chromosome cycle and that such bodies of varying number, although they may be of constant number in a definite stage, can be taken neither for genes nor genic loci. Recently, however, cytologist's attention was drawn again to chromomeres. Also Johannsen writes in 1926, in the new edition of his well known 'Elemente': "Es ist höchst wahrscheinlich, dass die verschiedene Gene, die z. B. für erbliche Abnormitäten der Bananenfliege verantwortlich sind, in oder an je einem Chromomere lokalisiert sind....." Quite recently a renewed study of chromomeres and chromioles has been made by Belling in a number of plants, and ultimate chromomeres and chromioles were claimed at first to represent genes themselves, but in his subsequent publication each gene is considered to be located in each chromiole.

If this chromiole theory is correct, which seems probable, we may

say in the same sense that atoms and molecules were made visible, as it were, by the introduction of x-ray photography and ultramicroscopy respectively, that now genes or individual genic loci have been demonstrated under the microscope, and the 'law of linear relations in the arrangement of genes' has been explained.

Before accepting this chromomere and chromiole theory definitively, however, it is desirable to know the relation between chromomeres and chromonema, and also to ascertain, by way of precaution, whether the number of chromioles in a nucleus is constant throughout the stages of the chromosome cycle.

As the result of intense study in genic analysis it became also apparent that there exist various cases of non-Mendelian inheritance.

The problem of sex determination in plants, which made a new start in the light of the results of the renowned experiments by Correns in 1907 and onwards, also took a considerable step forward through the discovery of sex-chromosomes, which are, as far as I am aware, now known in about 53 phanerogamous plants and a number of cryptogams. Here, as in most other cases, genic analysis lighted the way, and cytology followed it.

In 1912 a quantitative theory of sex-determination and later of inheritance in general has been advocated by Goldschmidt, and is now gaining a general acceptance. In a few cases, numerical values for the effect of certain genes have been determined; e.g. for genes determining pod-length in certain crosses in *Stizolobium* (Belling, 1915), for those determining the ear and awn lengths in *Hordeum sativum* (Takezaki, 1927, 1928). Although the quantitative study of genic values is still meagre, at least in plants, it is, in view of analogy with the law of multiple proportion in chemistry, of prime importance, and a rapid development of genetics in this line is now to be anticipated.

Recently, even artificial modifications of genes, thereby inducing alteration of characters, have been undertaken, in some cases with success.

Thus, by genic analyses, supplemented by the morphological and experimental study of internal structure and processes, our knowledge of the mechanism of heredity and variation is making striking progress, and exerting important effect on other principles of biology.

There is, however, one thing which was neglected both by geneticists and cytologists, i. e. the study of the series of external and internal developmental processes and accompanying reactions intervening between the characters on one hand and the genes on the other. A

character in a definite part of the body develops under the influence of the genes and the intra-cellular substratum, external milieu, and other parts of the body, and in cases of maternal inheritance plastids and other plasmic constituents act instead of the genes. Among others, the study of the mechanism of development in connection with the influence of the genes must be specially insisted upon for the future efforts of investigators. Goldschmidt's recent attempt in this relation may be noted here.

It has been sometimes said also that genetics has an appearance of being a play of numbers and symbols, the outcome of a long series of experiments being a group of arbitrary symbols seemingly with empty contents, neither the morphological nor chemical nature of genes which the symbols imply being known to us, and having been hitherto understood to lie beyond our recognition by sight. But the use of symbols and numbers to represent certain entities established as a logical conclusion to account for the result of experiments is just what is adopted in chemistry, and is a correct scientific procedure. Genetics and chemistry have a point in common in this respect. One grave difference in the use of symbols exists between them at present, however, viz. in chemistry symbols for elements are used each with a definite name with its quantitative and qualitative attributes, which is universally adopted among all chemists, while in genetics of the present day, one and the same symbol is often used by different authors for different genes, and the same author uses different symbols in different plants, and even on different occasions for the same gene,—a state of affairs which should not be allowed in an exact science, and the very cause of the impression that genetics is a play of numbers and arbitrary symbols.

So it is a pressing need now to undertake the unification of the use of symbols in genetics. For this purpose we must have a general survey of all important results hitherto obtained by genic analyses, especially of all of the established genes, and a thorough comparative study of them must be undertaken. Thus a comprehensive monograph on genic analysis is demanded.

Besides, there is a vast amount of materials accumulated as the result of various activities of more than five hundred investigators during the first quarter of this century, and they are so widely scattered in various journals of different languages, that it is extremely difficult for one to have a general view of them, or to find out any desired material in particular, and here, too, a need of a concise and yet comprehensive work of the nature of a general review, together

with bibliography, seems to be felt by every student of genetics. In the absence of a work of the kind at present I may commend the present work of Mr. Matsuura as meeting such a need, although for more detailed information original papers must be referred to, and 'Bibliographia Genetica', so far as the plants treated in the latter are concerned, will be an admirable source of reference.

Finally I take this opportunity of expressing my warm thanks to Mr. Tokushichi Nomura, Member of the House of Peers, by whose and his brothers' donation of a fund the chair of Genetics in the Faculty of Science, Tokyo Imperial University, was opened in 1917, and by whose donation made in 1927 especially for the publication of Mr. Matsuura's present work, the printing of this monograph, the compilation of which was undertaken while I was in charge of this chair, was made possible, for his generosity and the interest shown in the promotion of the science of genetics.

K. Fujii

Tokyo, *March 1929*

AUTHOR'S PREFACE

The great interest that has been shown during the last twenty-five years in the study of Plant Genetics has led to the rapid development of this branch of biology. The scope of the work has been very widely extended; the data obtained have become more and more complex and amplified. Now it seems, therefore, to be desirable to attempt to bring together the results of previous workers in this field. The need of such a work has been keenly felt by the author himself. Whatever experimental work the research worker in Plant Genetics may engage in, the first thing to know is that what kinds of plants have been extensively investigated and what others still remain to be investigated.

The present work has been prepared to meet such a need. Extent of the work, however, was for the present restricted to the matters concerning the genic analysis in phanerogamous plants only and publications which appeared during the years 1900-1925. The account of the publications of later date as well as the data concerning cryptogamous plants will be added subsequently.

This work has been undertaken by the author since 1923 under the direction of Prof. K. FUJII. In the meanwhile the admirable work 'Bibliographia Genetica' edited by Dr. LOTSY and Dr. KOOLMAN began to appear, and already three volumes have been issued. But for the fact that most of the text of the present work had then already been written, the author might have hesitated to pursue his project. The papers in *Bibliographia Genetica*, however, have a very wide scope, and are written from a more critical point of view than the present work, so that there seemed still to be room for a review of the previous works in a concise and more convenient form.

An attempt to compile such a bibliographical work in Japan is no easy matter. The author even felt it at first quite hopeless, as many of important papers were inaccessible, though he has visited not less than

ten well-known libraries in this country. Under such an unfavourable condition, he was obliged, in some cases, to his deep regret, to content himself with relying only on reviews or résumés, instead of referring to the originals. And so any information about inaccuracies and omissions is earnestly solicited.

The author wishes to express his sincerest thanks to Dr. K. FUJII, Em. Prof. of Botany, Tôkyô Imperial University, for the suggestions, criticisms and encouragement given him during this work. In connection with the facilities afforded for approaching various publications, he is indebted to Dr. H. HATTORI, director of the Tokugawa Biological Institute, Em. Prof. S. IKENO of the Tôkyô Imperial University, Dr. KAGAYAMA, director of the Tôkyô Sericultural Experiment Station, Dr. KONDO, director of the Ôhara Agricultural Institute, Dr. K. MIYAKE of the Tôkyô Imperial University, Prof. TAHARA of the Tohoku Imperial University, Dr. TERAÔ of the Tôkyô Agricultural Experiment Station, and Prof. YAMAGUTI of the Tohoku Imperial University. His thanks are also due to many others who have rendered assistance.

H. Matsuura

Sendai, *March 1928*

Part I

Genic Analysis in Plants

N.B.—Numbers in brackets after Authors' names refer to the works in the Bibliography (Part II)

Agrostemma Githago

DE VRIES (8, 56). The presence of pigment in flowers is dominant to its absence.

Allium Cepa

Color of the Bulb. According to TSCHERMAK (475), dark yellows and red colors are dominant to white in F_1 . In F_2 a complex segregation was observed, and in F_3 some white individuals produced white and colored.

MEUNISSIER (567) reports that several genes are concerned in the coloring of the bulb; in general, yellow behaves as a dominant over red and white, but a recessive yellow is also found.

Chlorophyll Deficiencies. RASMUSON (735) has observed several abnormalities in chlorophyll development: white, yellow, chlorina and T-chlorina. The white and yellow seedlings perish within 2 or 3 weeks time after germination. The chlorina form appears yellowish-green at first, but later it may become greenish, so that the plant may mature under favorable conditions. The T-chlorina is somewhat paler in color than the chlorina and is nonviable. He found that some green plants, when selfed, gave:

- 1) Green and white in a theoretical ratio of 15:1 (the numbers obtained being 51 and 2);
- 2) Green and yellow, green and chlorina, green and T-chlorina, in each case in a ratio of 3:1; in some cases green and chlorina in a ratio close to 15:1;
- 3) Green, chlorina and white; green, chlorina and yellow in both cases in a 9:3:4 ratio.

It has been inferred that the complete production of chlorophyll depends on a set of genes, i. e., Z_1 standing for yellow seedlings, its

absence resulting in white, Z_2 being homomeric with Z_1 , Y producing—together with Z_1 or Z_2 —the chlorina form, N_1 changing chlorina color into normal green and N_2 being homomeric with N_1 . The difference between green and T-chlorina is due to a single gene T . The relation of this gene to the others has not yet been fully elucidated. Thus the scheme of the genic composition may be represented as :

$N_1(\text{or } N_2)Z_1(\text{or } Z_2)Y$		green,
$n_1n_2Z_1(\text{or } Z_2)Y$		chlorina,
$n_1n_2Z_1(\text{or } Z_2)y$		yellow,
$N_1(\text{or } N_2)Z_1(\text{or } Z_2)y$	}	 white.
$N_1(\text{or } N_2)z_1z_2Y$		
$N_1(\text{or } N_2)z_1z_2y$		
$n_1n_2z_1z_2y$		

Althaea

SAUNDERS (511) made some observations on the inheritance of doubleness in the flowers of *Althaea rosea* (Hollyhock) and *A. ficifolia* (Antwerp hollyhock). The F_1 plants showed intermediate characteristics. In F_2 the ratio was 1 single : 2 intermediate : 1 double, indicating a monogenic difference.

Amaranthus caudatus

DE VRIES (56). The red-leaved type is dominant to the green-leaved variety.

Anagallis arvensis

WEISS (212) made some observation on the inheritance of flower color of this plant. Crosses between scarlet and blue varieties produced F_1 plants with scarlet flowers, except that in one or two flowers out of several hundreds a small blue streak was observed. In F_2 segregation was complete, but not in the ordinary Mendelian ratios. The cross, blue $\times$ scarlet, gave 62 scarlet and 8 blue, while its reciprocal gave 25 red and 2 blue.

HERIBERT-NILSSON (241) crossed a variety having pink, almost white flowers with the red flowered type. The F_1 plants had flowers like the red type. In F_2 there was segregation into red and pink in a ratio of 3 : 1.

Andropogon Sorghum

Grain Color. Several experimentors have worked with this plant. According to GRAHAM (442), red and yellow in the grain are sap colors. He found the monogenic difference between red and yellow, red and white, and yellow and white. One of the crosses between yellow and white gave different results, producing a red F_1 . In F_2 segregation into 9 red : 3 yellow : 4 white was obtained. His explanation is that certain white grained plants are undeveloped reds requiring the presence of yellow to cause the red color to develop.

VINALL & CRON (854) crossing brown (Blackhull) with white (feterita) obtained a close agreement to 9:7 ratio for brown and white grain. Two genes were assumed, **B**: a gene for brown color carried by the Black-hull kafir, and **S**: a spreader gene carried by the feterita.

CONNER & KAPPER (996) worked with natural crosses between Dwarf White milo und Dwarf Yellow milo, Red kafir and White kafir, and Pink kafir and White krafir. It was found that Yellow milo seed coat behaves as a complete dominant over the White milo seed coat, while F_1 of Blackhull White kafir $\times$ Red kafir have a pale red seed coat, almost exactly intermediate, and a similar condition of intermediacy is found in F_1 of Blackhull White $\times$ Pink kafir.

Recently SIEGLINGER (1213) made more extensive observations on this subject, using the following several varieties: feterita (chalky opaque white), Blackhull kaoliang (chalky opaque white), Sunrise kafir (creamy white), White kafir (white), and Red kafir (dark red). The grains of feterita and Blackhull kaoliang have a well developed brown nucellar layer lying directly outside of the aleurone layer. In grains of the others, no brown layer is present. The result from crossing may be summarized as:

1) White with brown nucellus (designated as 'white +') and white with no brown nucellus (designated as 'white -') gave light 'brown +' F_1 , and in F_2 9 'light brown +': 3 'white +': 4 'white -'.

2) 'Dark red -' and 'white -' gave dark 'red -' F_1 , and in F_2 3 'red -': 1 'white -'.

3) 'Dark red -' and 'white +' gave 'reddish brown +' F_1 , and in F_2 45 'brown +': 3 'white +': 12 ('red and pink -'): 4 'white -'.

4) 'White -' and 'white -' gave white offspring only.

These results were explained on the assumption of three genes; **B**: a gene for brown nucellar layer, which produces brown color in the

epidermis in the presence of **S**; **S**: a gene causing the development of color in the epidermis of the grain; **R**: a gene for dark red causing the development of red color in the epidermis. The scheme of the genic composition may be represented as:

BSR	}		brown with brown nucellar layer,
BSr			
BsR			
bSR (Red kafir)	}		red and pink with no brown nucellus,
bsR			
Bsr (feterita & Blackhull kaoliang)			white with brown nucellus,
bsr	}		white with no brown nucellus.
bsr			

Glume Color. According to VINALL & CRON (854), where Red amber sorgo was used as the pistillated parent in several crosses, the red in its glumes was dominant to the black in glumes of feterita, and the results indicated only a single gene difference between red and black glumes. Similar results were obtained by RAMANATHAN (1204). The latter author also found that red apexed glumes are dominant to self-colored, with a single gene involved.

Chlorophyll Deficiencies. CONNER & KAPPER (1121) observed albino seedlings in a plot of Standard Blackhull kafir and noted other seedlings which appeared to be virescent white. The albino type seemed to be recessive, but the mode of inheritance has not been definitely determined.

Other Characters. As to the inheritance of several other characters studied, see TABLE I.

TABLE I.—INHERITANCE OF CHARACTERS OF *Andropogon Sorghum*.

Contrasted characters	F ₁	F ₂	Authors
Long—short glumes	(Short)	3 short : 1 long	GRAHAM (442)
Broad—narrow glumes	Broad	3 broad : 1 narrow	VINALL & CRON (854)
Wrinkled—non-wrinkled glumes	Wrinkled	3 wrinkled : 1 non-wrinkled	RAMANATHAN (1204)
Awned—awnless glumes	Awnless	3 awnless : 1 awned	{ VINALL & CRON (854) RAMANATHAN (1204)
Pubescent—glabrous glumes	Pubescent	3 pubescent : 1 glabrous	
Red pediceled—non-red-pediceled spikelets	Red	3 red : 1 non-red	{ RAMANATHAN (1204)
Open or loose—compact heads	Open	3 open : 1 compact	
Pithy (dry)—sweet (juicy) stem	Pithy	3 pithy : 1 sweet	HILSON (447)

The juicy-stem variety has a dull white (generally interrupted with green) midrib of the leaf, while in the dry variety the midrib is marked with a white band running through the whole length of the leaf.

Anemone

HILDEBRAND (4) reports that blue flower color (*Anemone Hepatica*) is dominant to white (*A. acutiloba*), and a cross, light blue (*A. angulosa*) $\times$ dark blue (*A. Hepatica*), gives an intermediate colored F_1 .

ROSÉN (419, 1206) working with several varieties of *A. Hepatica* showed that blue and red are dominant to white. Red and white often gave blue in F_1 and a 9 (blue) : 3 (red) : 4 (white) ratio in F_2 .

Antirrhinum majus

Flower Color. As far as anthocyanin pigmentation in the flower of *Antirrhinum majus* is concerned, three groups may be classified :

- 1) Magenta anthocyanin group,
- 2) True red anthocyanin group,
- 3) Non-anthocyanin group.

The last group contains white, yellow (due to luteoline) and ivory (due to apigenin). The typical color of the second group is rose doré which when superposed with yellow produces a bronze color. Both the rose doré and bronze occur in the tinged, pale and intermediate shades. Similarly magenta anthocyanin, if superposed with ivory, gives magenta; and if mixed with yellow, produces crimson. Likewise various shades occur in this group. Further varieties occur in which the lips are colored and the tube is colorless; to these types is applied the term 'delila.'

The inheritance of color in these varieties is very complex. Extensive works have been done by ONSLOW (WHELDAL) (84, 125, 150) and BAUR (67, 88, 127, 158, 216, 1110). The earlier works of DE VRIES (13) and BATESON (14) have also been reviewed and discussed by ONSLOW. According to the latter author, generally speaking on the inheritance of the flower color, magenta is the most epistatic color and yellow is the most hypostatic color. The monogenic difference was found in the following pairs of colors: crimson—bronze, bronze—yellow tinged bronze, magenta—rose doré, rose doré—ivory tinged rose doré. Delila forms (e.g. crimson delila) are recessive to corresponding non-delila (e.g. crimson).

According to ONSLOW, at least seven genes are concerned in the flower color of the snapdragon. Six of these are :

Y: a gene causing yellow color in the lips and ivory in the tube, its absence resulting in white.

- I:** a gene causing ivory color in the lips. Heterozygously **I**-effect is weakened.
- L:** a gene causing red-tinging in the lips.
- T:** a gene causing red-tinging in the tube.
- D:** a gene causing intensification of the magenta color in the lips and tube. In **LL** plants the presence of **D** produces pale magenta, whereas **LL** plants containing **D** are intermediate magenta.
- B:** a gene converting red into magenta color. This gene leads also to the formation of anthocyanin in the stem and leaf.

The genes **I**, **L**, **D**, **T** and **B** can only be manifested in the presence of **Y**. **I** with **Y** gives ivory. **L** with **Y** gives crimson, but with **I** in addition it gives magenta. **T** and **D** can only be manifested in the presence of **L**. The presence or absence of these six genes in various combinations has given rise to the numerous color-varieties, i.e.

YILTDB	self-colored magenta (e.g. wild form, Carmine king),
YILtDB	magenta delila,
YiLTDB	crimson (e.g. Crimson king),
YiLtDB	crimson delila,
YILTDb	rose doré,
YILtDb	rose doré delila,
YiLTDb	bronze,
YiLtDb	bronze delila,
YILTdb	ivory tinged rose doré,
YILtdb	ivory tinged rose doré delila,
YiLTdb	yellow tinged bronze,
YiLtdb	yellow tinged bronze delila,
Yil(TDB)	ivory,
Yil(TDB)	yellow (e.g. Yellow prince),
y(ILTDB)	white.

According to this scheme, the formation of anthocyanin is dependent upon the presence of two genes: **Y** and **L**, whereas BAUR established still further important so-called basic genes (der Grundfaktor of BAUR) for the anthocyanin formation. A number of genes including these, described by him, are as follows:

B¹: a gene identical with ONSLOW'S **Y**.

1) BAUR observed an interesting fact concerning the effect of the **B** gene. He noticed that all **bb** plants are distinctly weaker in growth and are smaller than those which possess the dominant gene **B**. Plants possessing the recessive gene may be recognized in the seedling stages by a peculiar coloration of the edges of the leaves and even better by the characteristic epidermis of the leaf blades.

- F**: a basic gene for red coloration. Its effect is partially identical with ONSLOW's **L**.
- D**¹⁾: a gene identical with ONSLOW's **T**.
- C**: a gene identical with ONSLOW's **I**.
- A**: a gene identical with ONSLOW's **B**.
- L**²⁾: a gene causing intensification of the magenta color. Heterozygously, **L**-effect is weakened.
- Ebu**: a gene causing intensification of **B**. **Bebu** plants are intermediate yellow-flowered, while **BEbu** plants have an intensive flower color.
- S**₁: a gene regulating the distribution of color between the full color and 'rosarücken.'
- S**₂: a gene regulating the distribution of color between the full color and 'coloratum.'
- G**: a gene causing the marbled pattern ('picturatum') as opposed to the uniform coloration. Heterozygously **G**-effect is weakened.
- V**: a gene causing a dark coloration of the vascular bundle in all parts of plants. This gene manifests itself only in the presence of the genes, **B**, **F**, **Pal**₁, **Pal**₂, and **X**.
- Pal**₁: another basic gene for the formation of the red pigment. Plants possessing **B** and **F**, but lacking **Pal**₁ are free from anthocyanin. Heterozygously, **Pal**₁-effect is weakened.
- X**: a gene causing the difference between the full color and 'rot an Röhre' in which the pigment is limited to the base of the corolla. The gene **X** also behaves as another basic gene for anthocyanin development. **Fs₁x** and **FS₁xd** plants are ivory-colored as well as **f** plants.
- Pal**₂: a gene intensifying the effect of **Pal**₁.
- Pal**₃: a gene, together with **Pal**₁ and **Pal**₂, converting flesh color into pale red ('rosa').
- Pal**₄: a gene, together with **Pal**₁, **Pal**₂ and **Pal**₃, converting pale red into typical red.

1) BAUR reports that all **dd** plants, in the presence of other color genes, may produce anthocyanin in the epidermal cells of the leaf blades, but the epidermis of the leaf-stalks and stems are practically free from the pigment.

2) Plants possessing the **L** gene are deep magenta, whereas according to ONSLOW, in certain varieties, magenta deeper than intermediate magenta behaves as a recessive character to intermediate magenta.

J₁: a gene causing uniform distribution of colors, its absence leading to a pale blotched condition 'maculosa.'

J₂: a gene causing uniform distribution of colors, its absence leading to a streaked condition.

The genes, Pal₁, X, Pal₂, Pal₃, Pal₄, J₁ and J₂ were found to constitute a series of septuple allelomorphs, or, according to his terminology, they are 'unilocale Faktoren.' Thus as far as these genes are concerned, the color varieties may be represented as:

Pal₁XPal₂Pal₃Pal₄J₁J₂ magenta,
Pal₁XPal₂Pal₃Pal₄J₁j₂ magenta striped ('rubrostriata'),
Pal₁XPal₂Pal₃Pal₄j₁j₂ blotched ('maculosa'),
Pal₁XPal₂Pal₃pal₄j₁j₂ pale magenta,
Pal₁XPal₂pal₃pal₄j₁j₂ ivory tinged magenta,
Pal₁Xpal₂pal₃pal₄j₁j₂ ivory tinged pale magenta,
Pal₁xpal₂pal₃pal₄j₁j₂ 'rot an Röhre',
pal₁xpal₂pal₃pal₄j₁j₂ ivory.

The genes S₁, S₂ and G were also found to form a system of triple allelomorphs.

As regard the inheritance of other characters, our knowledge is principally due to the extensive works of BAUR (67, 127, 157, 524, 603, 869, 1110). A number of abnormal types, many of which occurred as mutants in his cultures, were named and genetically investigated.

Flower Characters. The following several abnormal types are in general simple recessive to the normal type in inheritance. The letters in the brackets represent the genic composition.

1) Chlorantha (chlchl). The type has somewhat reduced flower-lips and the outside of the upper-lips is partially colored green.

2) Choripetala (kk). This is another deformed flower-type, in which the corolla partially adheres together. Without artificial fertilization, choripetala-plants produce only few seeds.

3) Cornuta (corcor). This recessive type is characterized by small horny excrescences developing on the outside of the flowers and also by a very narrow flower-tube. The ovaries are often very small and more or less sterile.

4) Ericoides (erieri). In this type, corollas are considerably reduced and anthers are sterile, but the pistil is normal and functional.

5) Globifera (gligli). The plants are characterized by the replacement of the flowers by the flower-like organs infolded by calyx-like scales. The globifera-individuals act as the female, anthers not developing. The gene gli is very unstable, reversing often into the dominant condition. This reversion occurs vegetatively as well as sexually.

6) Globosa (mm). The plants resemble globifera in appearance. In this type, the flower is replaced by a branching shoot which bears several deformed flowers.

7) Nicotianoides (ww). The corolla is strongly reduced and colored green, and the anthers are so deformed that they are completely sterile. The ovaries and stigmas, however, are normally developed and may give plentiful seeds in crosses with other varieties. When this type is combined with other abnormal types, very curious forms result (e.g. radialis-nicotianoides).

8) Radialis (ee). The flowers are radial, instead of having the normal zygomorphous form.

9) Sterilis (hh). The plants are characterized by completely verdant flowers which are composed of compact calyx-like scales. The form is only obtainable through parental stock heterozygous for the gene.

10) Variabilis (pp and qq). The plants show conspicuous variation in the flower form, bearing in one individual various flowers, radial, zygomorphous and of several gradations of intermediacy between them. The effect of the gene p differs slightly from that of q. The heterozygotes, PpQq, which are normal-flowered, show segregation into normal and variabilis in a ratio of 9 : 7.

In addition to these, there are also several other forms, i.e. flexuosa (oo), reflexa (refref), rhinantoides (rhirihi) and phantastica (phasphas). They were also found to behave as simple recessives to the normal type.

Leaf Characters. The following two abnormal types of the leaf are described by BAUR.

1) Graminifolia (uu). The leaves develop rather narrowly, as also do other leaf-organs, such as calyx, corolla, etc. The graminifolia type of wild species (e.g. *A. tortuosum*), however, was found to be genetically different from that of *A. majus*.

2) Crispa (Cricri). This type is the only dominant mutant found by BAUR in *Antirrhinum*. The leaves are irregularly wavy. An anatomical study indicates that there is partial failure of the epidermis to develop. Crispa-plants may mature and develop good flowers, although the plants are distinctly weaker in growth and smaller than the normal

type. The dominant gene Cri, when homozygous, has a lethal effect; consequently all crispa-plants are heterozygous for the gene (Cricri).

As to chlorophyll development, numerous abnormalities have been also observed in the snapdragon, most of which behave as simple recessives giving a 3 : 1 ratio in F_2 of a cross between the normal and abnormal forms. They are as follows :

1) Acroxantha (acracr). The acroxantha type is characterized by yellow leaf-tips which are recognizable only in the seedling stage.

2) Albida (albalb). In this type, there is a complete failure of chlorophyll development; consequently the seedlings perish within a few days.

3) Albostriata (zz). The leaves show green blotches on a white ground. A cytological study indicates that the white cells contain plastids, but they are colorless and smaller than those in the normal green cells.

4) Albovirens (rr). The albovirens germinates with completely white cotyledons. But gradually a small amount of chlorophyll develops which may increase under favorable conditions so that the plant may mature, although it will be very weak.

5) Aurea (Nn). The aurea types are golden-leaved. They give in selfing green, aurea and yellow in a ratio of 1 : 2 : 1, indicating that they are always of monogenic hybrid nature. The pure recessive yellow seedlings perish within a few days after germination.

6) Flavescens (flavflav). In this type, the leaves are pale green, the normal green component of chlorophyll being somewhat suppressed. The flavescens type is not very vigorous toward maturity.

7) Lutea (lutlut). The lutea type gives seedlings with a yellow color. Plants heterozygous for this gene are normally green in appearance and produce a mixed progeny of which 25% are pure yellow and 75% green.

8) Luteovirens (luvluv). The plants appear yellow at first, but under favorable conditions they gradually become yellowish green, resembling the albovirens type.

9) Marmorata (marmar). The leaves are marbled with green or pale green.

10) Perlutea (tt). In this type, the leaves are somewhat yellowish-green and much smaller than those of the normal plants. The recessive

gene **t** was found to suppress the anthocyanin development in the flowers and leaves.

Stem Characters. There are also abnormal stem types which are simple Mendelian recessives to the normal type.

1) Gracilis (**gragra**). The plants are much weaker and more slender in growth than the normal. Especially the leaves are distinctly small and the internodes are also somewhat shortened.

2) Fasciata (**fasfas**). The expression of the gene **fas** for the fasciated stem is highly dependent upon environmental conditions. Consequently there is considerable variation in the appearance of different plants of this type, but genetically all behave alike.

3) Brevis (**brebre**). The plants are nearly half as high as the normal type. The sexual organs are non-functional, the anthers producing only abortive pollen and the female organ also being sterile.

4) Monstrosa (**yy**). This variety shows almost normal growth in the seedling stage, but when about two months or more old, the stems betray symptoms of fasciation. There is also considerable variation in the flower form, some flowers developing nearly normally, the others being strongly deformed.

Self-sterility of Several Antirrhinum. BAUR (602) investigated the self-sterility of several species of the genus *Antirrhinum*. *A. siculum* and a wild Spanish form of *A. majus* are perfectly self-fertile, while *A. latifolium* and *A. tortuosum* and two wild forms of a Portuguese species are self-sterile during the first year and self-fertile in the next. *A. Iban-yezii*, *A. molle*, *A. glutinosum*, *A. hispanicum* and a form of Spanish species are fully self-sterile. BAUR found that in hybrids between self-fertile and self-sterile species self-fertility is dominant, a 15:1 ratio being obtained in F₂.

*Linkage Relations.*¹⁾ BAUR states that about 200 genes determined were bound in linkage groups. Papers, published hitherto, however, deal with only the first chromosome (BAUR, 158, 216, 524, 525, 1110). In this chromosome, the gene complex, **Pal₁-X-Pal₂-Pal₃-Pal₄-J₁-J₂**, was found linked together with the other complex, **S₁-S₂-G**, with about 20 per cent of crossing over (see under 'Flower Color'). But the value is very variable.

Recently HERZBERG-FRÄNKEL (1265, 1266) and SAULESCU (1301) report that there exists a linkage relation between the gene **A** (represent-

1) The haploid chromosome number in *A. majus* is 8. Vide TISCHLER's compilation of chromosome numbers in *Tabulae Biologicae*, Bd. 4. 1927.

ing magenta color) and **F** (its absence resulting in ivory flowers) with about 34 per cent of crossing over. The former author found also that likewise between **F** and **D** (its absence resulting in delila forms) about 34 per cent of crossing over occurs, but **A** and **D** indicated free combination.

Aquilegia vulgaris

Flower Color. KRISTOFFERSON (926) has published works on this plant. A dark blue-flowered plant showed segregation in the following generation into dark blue, red, light blue and white in a ratio of 9:3:3:1. Two genes were assumed, **R** and **B**:

RB		dark blue,
Rb		red,
rB		light blue,
rb		white.

The gene **R** was found to have a pleiotropic effect on several parts of the plants. When **R** is present, the anthocyanin formation occurs as well on the upper as on the lower-sides of the leaves; in the absence of **R**, the formation of anthocyanin is limited to the lower-side of the leaves. It was also noticed that plants possessing the dominant **R** gene are distinctly higher in stature, shiny (as contrasted with dull) in the testa, darker in endosperm color and greater in weight of seed.

KRISTOFFERSON established still another gene **C** from the study of the cross between the dark blue flowered and the white flowered plants. This gene governs the distribution of colors, its absence resulting in the white margined flower.

Chlorophyll Deficiencies. BAUR (157, 216) recognized the monogenic difference between the following pairs of chlorophyll types:

- 1) Green—chlorina (yellowish green), the green being dominant;
- 2) Variegata—chlorina, the variegata being dominant;
- 3) Green—variegata, the green being dominant.

The scheme of genic composition was represented as follows:

AB	}		green,
aB			
Ab			variegata,
ab			chlorina.

In the gametogenesis of the zygote **AaBb**, **Ab** and **aB** are supposed to be entirely coupled.

Arabis albida

CORRENS (613) described three types of periclinal chimeras in this species: leucodermis, pseudoleucodermis and chlorotidermis. The former two types have a white subepidermal layer and a green core, thus showing green and white in the leaves. The third type has a bright yellowish green cell layer below the epidermis and a green core, thus showing green and yellowish green in the leaves. Crossing experiments showed that the leucodermis type is determined maternally, that is, only through the egg cells, not through the pollen, while in pseudoleucodermis and chlorotidermis, white or pale subepidermal layer is due to a Mendelian gene which is recessive to *typica*, and in crosses with the *typica* race they show normal segregation. The same individual, however, contain the dominant gene for greenness of cells in a homozygous or heterozygous condition, thus indicating that the pale subepidermal layer and the green core are genotypically different.

Arachis hypogaea

According to VAN DER STOK (146), dark red brown color in the seed behaves as a dominant over pale red, giving in F_2 approximately a 3:1 ratio.

The same investigator made a cross of a race having small thin pods with another race bearing large thick pods. The results obtained indicated that several genes which have a cumulative effect are involved in the shape and size of the pod.

Argemone

CORRENS (28) made a cross between a yellow-flowered *A. mexicana* and a pale yellow *A. ochroleuca*. The F_1 plants were intermediate-colored, but nearer to the pale yellow parent.

According to MEUNISSIER (576), the cross, *A. mexicana* (yellow) $\times$ *A. platyceras* (white), gave the F_1 plants which show characters intermediate to those of parent with pale yellow flowers, while the F_2 plants included a number of completely new forms as regards color (chamois-skin color), the form of the flower (double), foliage, habit of growth, etc.

Arum maculatum

COLGAN (163) found that out of 11 seedlings raised from a plant

with black spots on the leaves, 5 were spotted and 6 unspotted. COLGAN suggests that the female parent was heterozygous for the spotted character.

Asparagus officinalis

NORTON (307) states that the resistance to the fungus, *Puccinia asparagi*, seems to be dominant to the susceptibility.

Aster Tripolium

According to DE VRIES (8, 56), the pigmented type is dominant to the colorless variety.

Atropa Belladonna

SAUNDERS (15) made crosses between *A. Belladonna typica* having brown flowers, black fruits and a stem tinged red and *A. Belladonna* var. *lutea* having yellow flowers and fruits and a pure green stem. In F_1 the color of the type was found to be completely dominant in the fruit (agreeing with the results obtained by DE VRIES, 8), but the color in stems and flowers was less intense than in the parent. Further results indicated that the difference between the type and the variety was monogenic.

Avena

COLOR INHERITANCE

Glume and Grain. In *Avena*, color of the grain is apparently in correlation with the color of the glume. The five principal colors of oats are black, brownish red, gray, yellow and white. These colors, however, are easily affected by environment, especially weather conditions at ripening. With bright sunshine a deeper color is developed than in wet, cloudy weather.

A detailed study on the inheritance of these colors was made by NILSSON-EHLE (119). A number of crosses showed monogenic differences between black and white, yellow and white, gray and white. Some crosses between black and white gave in F_2 a digenic ratio of 12 black : 3 gray : 1 white; black and yellow gave likewise a ratio of 12 black : 3 yellow (or yellowish) : 1 white. In another cross, yellow (Gold Rain) $\times$

black (Moss), the F_2 consisted of four types: black, yellow, gray and white. Some crosses of gray with yellow gave in F_2 gray, yellow, yellowish gray and white. These results were explained on the assumption of three color genes, **S** for black, **Gr** for gray and **G** for yellow. The genic scheme is as follows:

S(GrG) black,
sGr(G) gray,
sgrG yellow,
sgrg white.

It was further found that a certain black-white cross gave in F_2 15 blacks to 1 white, indicating that the black color is produced by two duplicate genes (**S**₁ and **S**₂). In addition to these main genes, there were found several modifying genes (**M**₁, **M**₂ etc.) which dilute the black color.

This explanation has been repeatedly confirmed by several investigators. WILSON (45), GAINES (1331), ZINN & SURFACE (520), all working with varieties of *A. sativa*, found the monogenic difference between black and white; SURFACE (470), LOVE & CRAIG (563) in crosses of a black *fatua* with a yellow *sativa* obtained a digenic segregation of 12 black : 3 gray : 1 white. And CAPORN (531) dealing with crosses between three varieties of *sativa* with *nuda* observed the following ratios in F_2 . Gray : white = 3 : 1, black : gray = 3 : 1 or 15 : 1, and black : gray : white = 60 : 3 : 1.

FRASER (621) made a cross between Burt, which produces yellowish red grains, and the Sixty Day variety, which produces yellow grains. He obtained an intermediate color in F_1 and in F_2 yellowish red, yellow and white in a ratio of 48 : 15 : 1. The results were explained by supposing Burt to carry two color genes, **R** for red and **Y** (NILSSON-EHLE's **G**) for yellow, and the Sixty Day variety one gene, **Y**¹ for yellow. Apparently **R** is epistatic to both **Y** and **Y**¹.

Stem. According to HAYES & GARBER (792), PRIDHAM (460) obtained the results showing that a reddish straw color behaves as a simple dominant over the green.

EAR CHARACTERS

Type of Panicles. According to NILSSON-EHLE (96, 119), the difference between the open-panicled and the side-panicled condition is due to several independent genes. The presence of either genes produces open panicles, while the absence of all of the genes results in

side panicles. The genes were shown to have a cumulative effect. When these genes are homozygous, a variety with a strongly open, lax panicle and drooping branches is obtained. An open-panicle form with obliquely erect branches ('Steifrispentypus') was found to differ by a single gene from the pure recessive side-panicle form. From crossing two 'Steifrispen' forms, he obtained in F_2 9 side forms out of a total of 112 plants. These side-panicle plants bred true, while of the 103 open-panicle forms, 24 again showed segregation, giving both open and side-panicle plants. Among the open-panicle segregates, some plants were more open than either of the parents.

GARBER (901) made crosses between Minota, an open-panicle oat, and Victory, a side-panicle Russian oat. The F_1 plants were open-panicle, but not to the same extent as the open-panicle parent. The F_2 segregation indicated that the panicle type is apparently dependent on a single main gene for its expression.

Awning. Oats show every degree of awning, from the one extreme, in which both florets (upper and lower) are strongly awned, to the other, in which neither florets show any trace of an awn. SURFACE (470) made a cross between a wild race and a cultivated oat, the former having heavy, twisted and geniculate awns on both florets, while the latter had none or very few on the lower grain and none on the upper. The F_1 plants presented an intermediate condition between the parents, awns being present on the lower grain of many spikelets but never on the upper grain. In F_2 a monogenic segregation following a ratio of 1 (no awns) : 2 (intermediate awns) : 1 (wild awns) was obtained. He suggests also that modifying genes are involved which produce awns in various intermediate degrees.

ZINN & SURFACE (520), crossing a *sativa nuda* with Victory, observed an evident relation between the kind of awn and the character of the hull. All naked grains bear only a thin, weak awn. On considering only the hulled and intermediate types of grain, there appeared to be a 3 : 1 ratio between plants with medium strong to strong awns and those plants with weak awns.

LOVE & FRASER (502), working with several varieties, made the crosses, weak awn $\times$ awnless (Burt $\times$ Sixty Day, Red Texas $\times$ Sixty Day). The F_1 plants were awnless, and the F_2 showed all degrees of awning, from the perfectly awnless condition to those awned like the awned parent. On grouping these forms in the three classes, he obtained a ratio of 1 awnless : 2 partially awned : 1 fully awned, or 1 fully awned : 3 remaining. The same manner of inheritance was observed in a

strong awned-awnless cross (*fatua* × Sixty Day). A similar result was obtained by FRASER (621).

Observations on the relation of the production of awns to glume color were first made by NILSSON-EHLE (362). From crossing an awnless yellow Sixty Day variety with an awned black cultivated oat, he found that the yellow oats segregating from the cross contained fewer awns than did the blacks, whites and grays. This negative correlation between awning and yellow color was explained on the assumption that the yellow gene acts as an inhibitor upon the production of awns. An analogous case was reported by LOVE & CRAIG (563) in the *fatua-sativa* cross. The yellow types possessed very few or no awns, making a sharp contrast to the blacks or grays which showed varying degrees of the awned condition from awnless to fully awned. A similar result was also reported by TSCHERMAK (592).

SURFACE (470) states, however, from his experiments that "while there is a slightly greater proportion of the yellow plants which are awnless than the other color, yet the difference can not be regarded as significant." Similarly LOVE & FRASER (502) report on a variety (Burt) containing a gene for yellow which does not inhibit awning.

FRASER (621), in the reciprocal crosses between the Sixty Day Variety and Burt, claimed that the second yellow gene, Y^1 , differs from the usual yellow gene in having no power of inhibiting the production of awns.

Hulled vs. Hull-less Grains. The hull-less or naked oats (*A. nuda*) are distinguished from the other species of *Avena* by several characteristics. The spikelets of the panicle are many flowered, varying from 4 to 9. The empty glumes and lemmas are similar in structure, being thin and membranous. The lemma and paleae do not clasp the kernel, the latter remaining loose or free within the chaff and readily separating in threshing. The awns are usually absent. The rachillas of the spikelets are much elongated so that the uppermost grains are borne well above the empty glumes.

Several workers—NORTON (79), NILSSON-EHLE (189, 362), ZINN & SURFACE (520), GAINES (1331), CAPORN (530), LOVE & McROSTIE (648)—have studied crosses involving a many-flowered hull-less grained oat as one of the parents. All investigators have obtained an intermediate condition in F_1 , with both kinds of grains, hulled and hull-less, borne in the same panicle. The F_2 segregation suggests a monogenic difference between the hulled and hull-less conditions which appear to be linked with few-flowered and many flowered spikelets, the presence or

absence of awns, and the brownish black or pale yellow color in the lemma.

As regards the various intermediate forms which CAPORN obtained concerning the structure of paleae, he tentatively put forward a three gene scheme; namely,

X: a gene capable of rendering all the paleae on the plant pure tight,

Y: a gene capable of rendering some of the paleae on the plant pure tight,

Z: a gene capable of rendering some of the paleae on the plant more or less sclerotised but never wholly tight.

Thus all pure tight forms are homozygous for **X**, no matter whether they contain **Y** or **Z**. Similarly all *nuda* forms are recessive for **X**, and they, too, may or may not contain **Y** and **Z**. Now if the **X** gene is heterozygously weakened in a way that some percentage of the paleae shall be pure tight, then crosses between the two classes will give the F_1 showing a wide range of variation, but all plants will throw in F_2 1 pure tight to 3 remaining including various intermediates and the pure loose type. This scheme agrees well with the results obtained.

Similarly LOVE & McROSTIE found considerable variation in the percentage of hulled and hull-less grains in different panicles of the same cross. They observed consistent correlation between the percentage of hulled grains on heterozygous F_2 plants and that of hulled grains on heterozygous F_3 plants. Some heterozygous F_2 plants with low percentages of hulled grains gave heterozygous progeny with correspondingly low percentages. A similar behavior was obtained in the progeny of heterozygous plants with high percentages of hulled grains, while plants with intermediate percentages of hulled grains gave heterozygous progeny with low, intermediate and high percentages in different plants. This suggests the presence of a gene which affects the percentage of hulled and hull-less grains of heterozygous plants.

Recently REED (1296), on the contrary, reports that the F_1 plants of his cross did not show the intermediate type of spikelets as described by other workers, the few-flowered hulled type being completely recessive.

Pubescence on Glumes. NILSSON-EHLE (96) studied the inheritance of this character. The basis of the glume is covered by either short or long hairs, or lacks them. Crosses between the long-haired and the short-haired variety gave the F_1 plants showing a mixture of both types of hairs and in F_2 a dihybrid segregation, throwing individuals having

no hairs as a 'novum'. Two genes were assumed, **L** for long hairs, and **K** for short hairs. The absence of both the genes results in the absence of hairs.

Fatuoid Type. In the sowings of cultivated oats, individuals are sometimes found that differ from the common type in the production of heavier awns, in heavy pubescence and in the basal articulation, resembling the wild oat, *A. fatua*. These aberrant forms are known under the name of Fatuoids. The progeny of the heterozygotes segregates into normal, heterozygous and fatuoid forms in a ratio of 1:2:1. Heterozygotes are less heavily awned than the fatuoid and have the fatua type of callus only on the lower grain (NILSSON-EHLE, 189, 825; ÅKERMAN, 750; GARBER, 900).

GRAIN CHARACTERS

Pubescence on the Back of the Grain. SURFACE (470) made the cross, *fatua* × *sativa* var. Kherson, the former being heavily pubescent on the back of each (upper and lower) grain, the latter lacking this pubescence entirely. The F_1 plants are pubescent on the lower grain, but smooth on the upper. As regards the lower grain, the F_2 segregation occurred in a 3 (pubescent): 1 (smooth) ratio, indicating that a single gene **P** was concerned. The gene **P** was found to be closely linked with the color gene **B** (for black). As for the lower grain, the F_2 consisted of smooth and pubescent plants in a 13:3 ratio. This suggests that the gene **s** for pubescence on the back of the upper grain is unable to act in the absence of **P**. Thus we get:

PS		lower grains pubescent, upper grains smooth,
Ps		lower grains pubescent, upper grains pubescent,
pS	}	 lower grains smooth, upper grains smooth.
ps		

These three types appeared in 9:3:4, or pubescent and smooth in 3:1.

On the other hand, LOVE & CRAIG (563) in the *fatua* × Sixty Day cross obtained in F_2 pubescent: smooth=57:7.¹⁾ They observed in this case, that all of the black oats are pubescent, the gray oats are pubescent or smooth (the ratio of pubescent: smooth=3:1), while the yellow oats have smooth grains. From these results they assumed that there are two genes

1) The numbers obtained were: 138 (both grains pubescent), 240 (one grain pubescent) and 42 (smooth).

for pubescence, one of which, P^1 , is linked with black and the other, P^2 , is independent of any color gene, and further that the yellow gene Y inhibits the production of pubescence in the absence of B (for black) and G (for gray). Thus the cross, *fatua* ($\widehat{BPGP^1Y}$) $\times$ Sixty Day ($\widehat{bpgp^1Y}$), gave in F_2 :

$BPGP^1Y$	}	 black, pubescent (48),
$BPGp^1Y$		
$BPgP^1Y$		
$BPgp^1Y$		
$bpGP^1Y$		gray, pubescent (9),
$bpGp^1Y$		gray, smooth (3),
$bpgP^1Y$	}	 yellow, smooth (4).
$bpgp^1Y$		

The actual results obtained were found to accord well with the theoretical ratio. In other crosses, *fatua* $\times$ Tartar King, they obtained in F_2 a 15 (pubescent) : 1 (smooth) ratio in one strain and also 3 : 1 in another. From these results where no inhibitory effect was produced by the yellow oats, the presence of two kinds of genes for pubescence in *fatua* was fully confirmed.

Pubescence at the Base of the Lower Grain. SURFACE (470) made some observations on the inheritance of pubescence at the base of the lower grain in his *fatua-sativa* crosses. On the grain of the wild parent the callus is surrounded on the dorsal and lateral sides with a ring of short stiff hair. On the grain of the cultivated race this pubescence is entirely absent. The F_1 plants showed an intermediate condition. There was no pubescence on the base of the upper grain of any plants except those with a typical wild base. In F_2 a 1:2:1 ratio was obtained.

ZINN & SURFACE (520) worked on a cross of *sativa* var. Victor $\times$ *sativa nuda*, the former having a long but rather sparse pubescence, while the latter lacked it. The character proved to be controlled by two independent genes, since they got a clear 15:1 ratio. They also found that in this pubescence two lengths of hair are involved, the long hairs being dominant to the short. A similar result had been secured by NILSSON-EHLE (96).

Type of the Base of the Grain. The base of the grain of the wild oat is expanded into a broad sucker-like ring which permits the grain to

1) B , of LOVE & CRAIG.

2) P , of LOVE & CRAIG.

shatter very easily, while the cultivated races possess a narrow-base which does not separate from the axis readily.

SURFACE (470), TSCHERMAK (592), and LOVE & CRAIG (563) showed that the cultivated type of the base is dominant or partially so to the wild type. The F_2 segregation was found to follow the 1 (wild): 3 (cultivated) or 1 (wild): 2 (intermediate): 1 (cultivated) ratio.

According to FRASER (621), *A. sterilis* differs from other oat species in having the upper grain adherent to the rachilla. The base of the lower grain resembles *A. fatua* in its articulation. In crosses between Burt belonging to *A. sterilis* and the Sixty Day Variety, the F_1 was intermediate, and in F_2 a ratio of 1 articulated base to 3 intermediate and *sativa* types was obtained.

As to the relation of the base to the grain color, SURFACE (470) concluded from the cross, *fatua* $\times$ *sativa* var. Kherson, that the gene for the 'cultivated base' of the grain inherits independently of the glume color genes. On the other hand, LOVE & CRAIG (563) working with *fatua* $\times$ *sativa* var. Sixty Day¹⁾ found that the black oats show segregation into the wild and cultivated forms as also do the grays, while the yellow oats exhibits no wild type of base but are all of the cultivated class. It seems that the yellow gene **Y** inhibits the production of the wild type of base in the absence of **B** (for black) and **G** (for gray).

Pubescence on the Pedicel. The wild oat has a very strong pubescence on the pedicel which bears the upper grain, while pubescence is in general absent from the pedicel on the cultivated oats. SURFACE (470) showed that the cultivated type is dominant in F_1 and the F_2 segregation is monogenic.

OTHER MORPHOLOGICAL CHARACTERS

Dwarfishness. WARBUTON (667) found dwarf plants in the Victory variety. The dwarf plants measured not over 9 inches in height. His results indicated that the dwarf character was due to a single recessive gene.

Later STANTON (1081) reported two cases of dwarf plants appearing in F_4 and F_6 of two crosses. In one instance the dwarfishness proved to be heterozygous giving a 3 (dwarf): 1 (tall) ratio, while in the other case it proved to be homozygous.

1) LOVE & CRAIG state that "this Sixty Day variety is identical with the Kherson as used by SURFACE so far as general varietal characters are concerned".

Height of Plants and Other Size Characters. In a cross between two *sativa* varieties which differed in height, NILSSON-EHLE (96) obtained transgressive segregation in F_2 . A similar result was obtained by SURFACE (470) in the cross, *A. fatua* (tall) $\times$ *A. sativa* var. Kherson (low). The results may be explained by the assumption of multiple genes.

NILSSON-EHLE (96) also made crosses involving leaf breadth, grain size and number of florets in the spikelet. In these cases occurred also trasgressive segregation, indicating that the character owed their expression to several genes.

Presence and Absence of Ligules. According to NILSSON-EHLE (119), the presence of ligules is dominant to their absence. Segregation was 3:1, but further segregation ratios were found, which suggested the presence of four independent genes.¹⁾ The absence of ligules was found to be always associated with the side-panicled form, suggesting that the genes for the open-panicle influence at the same time the development of the ligule.

Chlorophyll Deficiencies. CHRISTIE (766) studied the inheritance of the yellow striped leaf and found that this is inherited in a non-Mendelian manner. The green type (Moistard Grenadier) only exceptionally shows the segregation into green and striped descendants, and in very variable and indefinite proportions. As a rule the striped individuals out-number the green. Some of the green plants resulting from segregation are fixed, while the others are liable to segregation and the green type in turn can produce the striped.

ÅKERMAN (862) found seedlings which appeared a normal green at first, but gradually yellowed and perished in a short time when grown in the bright sunshine. In subdued light ($1/4$ – $1/5$ sunlight) defective plants retain their green color and mature grains. This form was called *lutescens*. Some green plants showed segregation in F_2 in a ratio of about 1 yellow to 70 green. By analysis of F_3 this was found to be in the ratio of 63:1 indicating three independent homomeric genes, all recessive to the genes for the normal green.

PHYSIOLOGICAL CHARACTERS

Resistance to Rust. PARKER (730) made a cross, Burt $\times$ Sixty Day, the former being resistant to crown rust, *Puccinia lolii avenae*, while the latter was susceptible to the same. The results indicated that suscepti-

1) The actual numbers obtained were as follows:—125:8; 220:5; 213:3; 547:2.

bility behaves as a partial dominant, resistibility as a recessive.

GARBER (786, 901), crossing White Russian oat (*A. sativa orientalis*) with other varieties (Minota and Victory), the former being resistant to stem rust, *Puccinia graminis avenae*, while the latter was susceptible, found that resistibility apparently behaves as a simple dominant character.

The inheritance of resistance to loose smut, *Ustilago levis*, has been studied by several workers. WAKABAYASHI (855) has published some data on the behavior of the progeny of a cross between Red Rustproof (resistant) and Black Tartarian (susceptible). He observed no smut among the F_1 and F_2 plants. In F_3 , however, a few infected individuals were found.

BARNEY (1109) made three different oat crosses, resistant (Fulghum) $\times$ resistant (Black Mesdag), resistant (Burt) $\times$ susceptible (Swedish Select), and susceptible (Turkish Rustproof) $\times$ susceptible (Golden Rain). He interpreted his results on the basis that in the first cross three different genes are concerned with resistibility, in the second two genes, and in the third only one gene.

REED & STANTON (1297) worked with a cross between Fulghum and Swedish Select, the former being very resistant to both *Ustilago Avenae* and *U. levis*, while the latter is susceptible to both smuts. The behavior of the F_2 plants was not recorded but that of the F_3 progeny was studied; some showed a degree of susceptibility corresponding to that of Swedish Select, a few of the progeny showed a much greater susceptibility, while still others a resistibility corresponding to that of Fulghum.

Another cross concerning the resistance to *Ustilago Avenae* was made by REED (1296): *A. nuda* var. *inermis* (very susceptible) $\times$ *A. sativa* var. *montata* (Black Mesdag, almost immune). In this cross the results indicated that resistibility is a simple dominant.

Ripening Time. Earliness and lateness are sharply defined characters for varieties of oats. From a cross between medium early and late varieties, NILSSON-EHLE (96) observed transgressive segregation in F_2 in which homozygous forms earlier than the early parent and also those later than the late parent were obtained. Of 112 F_2 plants, 98 proved to be heterozygous for maturity and 14 seemed to be homozygous.

CAPORN (531), in a cross between an early variety (Mesdag) and a late one (Hopetown), obtained F_1 individuals with a more or less intermediate condition. The F_2 plants were all harvested together and 106 plants tested in the F_3 . Two were homozygous for early maturity equivalent to the early parent. The lateness of the late parent was not recovered.

He interpreted these results on the assumption that earliness is possibly a function of three genes.

Recently NOLL (1292) studied earliness in a number of generations in crosses involving 15 varieties and strains pertaining to both *A. sativa* and *A. sterilis*. Some crosses gave the F_1 plants headed with the early parents, while others gave those earlier than the early parents. In some crosses in which the parents headed together, the F_1 plants were distinctly earlier than the parents. From these results it is clear that earliness is dominant to lateness. The data in the later generations supported the assumption of multiple genes. Homozygous races were obtained which are earlier than the early parents, similar to the early parents, intermediate, and later than the late parents.

Germinating Time. GARBER & QUISENBERRY (1010) found that grains of wild oats possess delayed germination and in crosses with *sativa* delayed germination is an inherited recessive character.

Abortive Pollen. According to GARBER (901), Victory, Minota and White Russian produced averages of 12.4, 1 and 0.9%, respectively, of abortive pollen grains. The F_2 segregation of a cross, White Russian $\times$ Victory, indicated that the abortive pollen as found in Victory was inherited as a recessive character involving at least two genes.

LINKAGE RELATIONS¹⁾

SURFACE (470), from his experiments with *fatua* $\times$ *sativa*, found that the wild base type of the lower grain is always associated with the following characters: (1) heavy awns on the upper and lower grains, (2) wild base type of the upper grain, (3) pubescence on the pedicel on the upper and lower grains, and (4) pubescence on all sides of the base of the upper and lower grains. As to the mode of inheritance of these characters, he states that "there is no evidence in the present cross to indicate whether these characters are due to the action of a single pair of genes or to several pairs completely linked. Evidence from certain other crosses, as yet not completely analyzed, indicates the existence of separate genes for some of these characters". Aside from these general characters, linkage was found by him between the gene **P** for pubescence on the back of the lower grain and the gene **B** for black color of the lemma. The results indicates 0.9 per cent of cross-overs between these genes. Likewise

1) The haploid chromosome number in *Avena fatua*, *A. sativa* and *A. sterilis* is 21. (Vide TISCHLER, *loc. cit.*)

LOVE & CRAIG (563) obtained similar results, but in his case no cross-overs appeared.

In the same paper, SURFACE reports also that the gene **S** for the cultivated type of the back of the grain and **C** for the cultivated type of the base are partially linked, with 1.52 per cent of cross-overs.

According to GARBER & QUISENBERRY (1010), delayed germination, a characteristic of wild oats, is somewhat loosely linked with the *fatua* type of grain articulation.

In a cross between Burt, belonging to *A. sterilis*, and Sixty Day, *A. sativa*, FRASER (621) found that the genes for the articulated base of the lower grain, the awned condition, and the production of medium basal hairs were linked in inheritance. The examination of F_2 and F_3 showed 5 per cent of cross-overs between the genes for awning and basal hairs, 4.14 per cent between awning and Burt base, and 1.79 per cent between Burt base and basal hairs.

As already stated, several characteristics of the naked oat appear to be governed by a single gene, as is also the case with those of the false wild (*fatuoid*) oat.

Barbaraea vulgaris

According to DAHLGREN (774), the normal green type is dominant to the variegated type. The data suggested that there are duplicate genes for the normal green type, the absence of both resulting in the variegation, a conclusion which was confirmed by ANDERSON (1104). The latter investigator states, however, that departures from normal Mendelian ratios are not infrequent, which must be attributed to segregation occurring in somatic tissues.

Begonia

BATESON & SUTTON (601) have published some data concerning the doubleness of flowers in *Begonia*. Double female flowers in a monoecious plant with terminal male and lateral female flowers, pollinated by a strain with only single flowers gave singles in F_1 ; but the segregation was irregular and not clearly analysed. A pure-breeding single-flowered *B. Davisii* from Peru which was used as the male parent in crosses with common doubles, gave only double-flowered offspring, contrary to usual behavior. A novel conclusion is drawn by the authors that this pure single-flowered form is genetically all double on the male side.

Berberis

Some observations were made by SAUNDERS (20) and HURST (40, 177) on the inheritance of several characters in this genus. Their analysis, however, has not been completely carried out.

Beta vulgaris

Root Color. KAJANUS (246, 251, 302, 499) has worked with a large number of varieties. As far as pigmentation in the root is concerned, four classes can be distinguished:

- 1) Red } with anthocyanin,
- 2) Rose }
- 3) White, in which the upper part is green } without anthocyanin.
- 4) Yellow }

He notes that the pigment is not always confined to the skin of the root. In the salad beet, the flesh is completely violet-red; in the common red beet it is red, reddish or colorless; in the rose and in the white it is colorless. The results from crossing may be summarized as:

- 1) Red and yellow gave red F_1 , showing segregation in F_2 in a 3:1 ratio;
- 2) Yellow and white gave red F_1 , showing segregation in F_2 in a 9 red: 3 yellow: 4 white (including rose) ratio;
- 3) Red and white gave red F_1 , showing segregation in F_2 in a 3:1 ratio in some cases, and in 9 red: 3 yellow: 4 white (including rose) in others.

Though the actual data showed some discrepancies from the theoretical ratios, KAJANUS established the following scheme of genes (also RASMUSON, 654):

GR red,
Gr yellow,
g(R) white.

An exceptional case was observed by KAJANUS, in which white $\times$ white gave red in F_1 .

A similar dihybrid segregation was also obtained by LINDHARD & IVERSEN (645). But they explained their results by assuming a loose linkage relation between **R** and **G**, with a percentage of crossing over equal to 36-38 per cent. This assumption agrees well with KAJANUS' data.

Leaf Color. Most varieties have green leaves, but in red beets the leaves are sometimes red. Quite red leaves occur in the case of red-fleshed beets. In red-fleshed beets there are also varieties in which the petioles and larger veins only are red, other leaf tissues being green. In crossing red with green varieties, KAJANUS (246) obtained results showing that in some cases the green color is dominant to red, suggesting the presence of an inhibitor for red, but in other cases green is recessive.

Form of the Root. KAJANUS (246, 251, 302) made numerous crosses with mangels and sugar beets to study the inheritance of root forms. The results from crossing showed that in general the wedge-shape was dominant to round, oval and also long, somewhat slender forms. A flattish round was found to be a pure recessive form. Most of the ratios obtained in F_2 could be satisfactorily explained on the basis of four genes: **L** for long forms, **O** inhibiting the effect of **L**, **A** for sharp forms and **B** inhibiting the effect of **A**. Another gene, **F**, was also identified by him, which causes crooking on the root surface and is dominant to its absence.

Biscutella laevigata

DE VRIES (56). The pubescent type is dominant to the glabrous variety.

Brassica Napus

See TABLE II.

Brassica oleracea

STEGLICH ('02, cited by HAYES & GARBER, 792) found blue-red foliage color dominant to green, and also head production (*capitata*-type) to headless character (*acephala*-type).

PRICE (195) used several varieties and made a number of crosses between them. In a cross between a crinkled-leaf cabbage (*B. o. capitata*) with a cauliflower (*B. o. botrytis*), the thick, leathery leaf of the latter was dominant; in a cross between varieties of crinkled-leaf and smooth-leaf cabbage, the former type of the leaf was dominant; in a cross between a head cabbage and a head-less one (*B. o. acephala*), the headed type was dominant; in a cross between kohlrabi (*B. o. caulorapa*)

TABLE II.—INHERITANCE IN *Brassica Napus esculenta*.

Contrasted characters	F ₁	F ₂	Authors
<i>Root Color</i>			
As regards color of the root, distinction must be made between that in the upper and lower parts. The upper part may be violet-red (anthocyanin), intermediate or green (chlorophyll), while the lower part may be white or yellow (both due to plastids in the flesh).			
Red—red	Red	Red : reddish green approaching to 3:1	KAJANUS (247, 302)
Red—green	Greenish red	Red, reddish green, green (Red: non-red = 3:1, or red : pale red: green = 12:3:1)	KAJANUS (247, 302) HALLQVIST (401)
Red—green	Green	Reddish green, green	KAJANUS (247, 302)
Two genes are involved in anthocyanin pigmentation, i. e., P ₁ for pale violet-red, and P ₂ for deep violet-red. P ₂ is epistatic to P ₁ . When both P ₁ and P ₂ are absent, the root is green (KAJANUS).			
<i>Lower part: (or flesh color)</i>			
Yellow—white	White		KAJANUS (247, 302)
Yellow—white	White	White: yellow = 15:1 or 3:1	HALLQVIST (401)
Two genes, M ₁ and M ₂ , are involved (HALLQVIST).			
<i>Leaf Shape</i>			
Pinnatifid—entire	Pinnatifid	Pinnatifid: entire = 15:1	HALLQVIST (443)
<i>Vegetative Duration</i>			
Biennial—annual	Biennial	Biennial: annual = (349) : (57)	MALINOWSKI (1193)

and cabbage, the thick stem of the former was dominant; in a cross between a cabbage and a cauliflower, the former type of head was dominant, and in a cross between cabbage and brussels sprouts (*B. o. gemmifera*), the determinate habit of growth was dominant. In all these cases no segregation was obtained in F₂.

SUTTON (103) found Thousand-headed kale foliage (narrow and thick; *B. o. acephala*) to be dominant to kohl-rabi foliage (broad and thin).

Crosses between kohl-rabi and Drumhead cabbage gave in F_2 non-kohl-rabi plants and plants resembling kohl-rabi in a ratio of 3:1. The parental forms did not appear in F_2 .

MALINOWSKI (811) explained the inheritance of head production and leaf-shape in a cross of *capitata* $\times$ *acephala* on a three gene assumption: A, B and C for head production, and X, Y and Z for curling of leaves. According to him, *capitata* has the genic constitution of AABBCcxyyz and *acephala* aabbccXXYYZZ, and there is coupling between A—x, a—X, B—y, b—Y, C—z and c—Z.

KRISTOFFERSON (806, 1178) has published more extensive works on this genus. Crosses between several varieties were made, i.e., cabbage $\times$ red cabbage, cabbage $\times$ kale, red cabbage $\times$ kale, cabbage $\times$ brussels sprouts, red cabbage $\times$ brussels sprouts, red cabbage $\times$ broccoli (*B. o. botrytis* sub-var.), cabbage $\times$ broccoli, brussels sprouts $\times$ kale and brussels sprouts $\times$ broccoli. The results obtained may be summarized as follows:—

1) Leaf color. The color of the leaf is a dark red violet in red cabbage and green in the other varieties. As to the color of the midrib red cabbage has red violet color like the rest of the leaf, cabbage and brussels sprouts light red, kale and broccoli green. The results of crossing showed that:

(a) The green type is a simple recessive to the light red type. Cabbage and brussels sprouts have thus one gene B, the absence of which in broccoli results in the green midrib.

(b) The green type in kale behaves quite differently. The color was dark red in the hybrid, and F_2 showed segregation in dark red, light red and green. The cross of cabbage $\times$ kale showed the following ratio: 8541 dark red, 2200 light red and 4396 green. The cross between brussels sprouts and kale rendered 530 dark red, 154 light red and 221 green. The observed ratio pro 16 is then 9.02:2.33:4.65 in the former, and 9.34:2.77:3.89 in the latter. Thus the light red plants always showed a marked deviation from the theoretical ratio. But dark red and non-dark-red gave almost exactly the theoretical ratio 9:7. These results were explained on three gene scheme, A present in the kale and B and C present in the cabbage or brussels sprouts. A in co-operation with C causes the dark red color, and B originates the light red color. Thus we get segregation in F_2 as follows:

$$\begin{array}{l} 27 \text{ ABC} : 9 \text{ AbC} : 9 \text{ ABc} : 9 \text{ aBC} : 3 \text{ aBc} : 3 \text{ Abc} : 3 \text{ abC} : 1 \text{ abc} \\ \hline 36 \text{ dark red} \quad : \quad 21 \text{ light red} \quad : \quad 7 \text{ green} \end{array}$$

The ratio of dark red to non-dark-red then will be 9:7 which agrees

well with the observed ratio. However the ratio of light red to green, according to this scheme, should be 3 : 1, a ratio differing still more from the observed one. The author ascribes this deviation to coupling between the gene **B** for light red and either of the gene **A** or **C**.

(c) The dark red violet color of the leaf in red cabbage behaves as a simple dominant character to the green in other varieties. The gene was symbolized as **D**.

(d) There is also another gene **E**, which is concerned with the distribution of the dark red violet color.¹⁾

As regards certain characters, the F_2 individuals are continuous between the extreme or parental types. These characters are given below:—

2) Head production. The hybrid, cabbage $\times$ kale, formed slack and pointed heads. The author says that "it is incorrect to characterize the power of running to heart as dominant."

3) The curling of the leaves.

4) Leaf shape. The shape of the leaves showed also a great variation in F_2 . For example, the cross between cabbage (rounded) and kale (narrow and pointed) gave a hybrid resembling the kale. Most F_2 plants had more or less intermediate leaves, but types similar to the parents were also obtained.

5) Waxy covering of leaves.

6) Height of plants.

7) Winter-hardiness.

8) Stem running.

Recently SUTTON (1219) reports on crosses between a green 'hearting' variety and a red 'bolting' variety of cabbage. The F_1 plants were all dilute red in color, and did not 'bolt.' In F_2 , although the number of plants raised was small, it points to a 9 : 3 : 3 : 1 ratio. The author states that bolting itself can hardly be regarded as a fixed character, but the tendency to bolt appears to be a simple Mendelian recessive.

The inheritance of disease resistance in cabbage has been studied by JONES (553). The disease is called 'yellows' and is caused by a soil-

1) The genic constitution of the varieties used may be represented as:

Cabbage	daBCE,
Red Cabbage	DABce,
Brussels Sprouts	daBCE,
Kale	dAbce,
Broccoli	dabCE.

infecting fungus (*Fusarium conglutinosus*). Crossing highly susceptible with resistant strains showed that resistance has a tendency to be dominant. There are indications that it is dependent on several genes.

Brassica rapa

See TABLE III.

TABLE III.—INHERITANCE IN **Brassica rapa esculenta**.

A summary of the results obtained by KAJANUS (247, 302).

Contrasted characters	F ₁	F ₂
<i>Root Color</i>		
Anthocyanin is found only in the upper part of the root, which may be violet-red (deeper or paler), or if pigment be absent, green or cream-yellow. It is often difficult to distinguish the yellow color from the others.		
Upper part:		
Green—red	Red	Red : green to yellow=3:1
Yellow—red	Red	Red : yellow, reddish yellow to greenish=3:1 ¹⁾
Yellow—green	Greenish yellow or green	Green : yellow=3:1
The results suggest that two genes are concerned: P for anthocyanin (red) and V for chlorophyll (green). Both the genes are heterozygously weakened. PV and Pv =red; pV =green; pv =yellow.		
Lower part (or flesh color):		
Yellow—white	White	White : yellow=3:1 ²⁾
The white color is due to the presence of one dominant gene, M , its absence resulting in yellow.		
<i>Flower Color</i>		
Orange—citron-yellow	Citron-yellow	Citron-yellow : orange=3:1
The gene for citron-yellow flower color is completely linked with the gene, M , for white flesh color.		
<i>Root Form</i>		
Round—long	Intermediate	Complex segregation
<i>Root Surface</i>		
Cracked—smooth	Smooth or intermediate	Smooth : cracked=3:1

1) & 2) Also HALLQVIST (401).

Species Crosses in the Genus Brassica. According to SUTTON (103), swede foliage (*B. campestris* var. *Napobrassica*) is a simple dominant to Ragged Jack foliage (laciniated leaves), and bulbing to bulblessness.

RAGIONIÉRI (731) crossed *B. chinensis* var. *Petsai* with *B. rapa*, with results not agreeing with those of SUTTON, i.e., F_1 plants were without sign of a bulb. The tendencies to produce a bulb and an entire leaf

TABLE IV.—INHERITANCE OF CHARACTERS IN THE CROSS, **Brassica**
Napus × **B. rapa**. From the data of KAJANUS (247, 302, 498).

Contrasted characters		F_1	F_2
<i>B. Napus</i>	<i>B. rapa</i>		
<i>Leaf</i>			
Grayish green	green	Intermediate	Grayish green: intermediate: green=1:2:1
Non-pubescent	pubescent	Intermediate	Pubescent: intermediate: non-pubescent=1:2:1
Bloom	no-bloom	Intermediate	Bloom: intermediate: no-bloom=1:2:1
Entire (Branc hâtif)	pinnatifid (Bortfedler)	Pinnatifid	Pinnatifid: entire=15:1
<i>Root</i>			
Round	long	Intermediate	Complex segregation
{ Red	yellow	Greenish red	Complex segregation
{ Green	yellow	Green	Complex segregation
Two genes for color of the upper part of the root were assumed: R for red and G for green, absence of both resulting in yellow.			
White (flesh)	yellow	White	3 white: 1 yellow
A single gene, W , is concerned in the flesh color. In some cases, however, the F_2 segregation suggests the presence of two or three homomeric genes for the white color. ¹⁾ —The white fleshed root is always accompanied with citron-yellow flowers, and the yellow root with orange yellow flowers.			
Contents of dry substances in the root:			
High	low	Intermediate	Complex segregation

1) HALLQVIST (401) actually obtained a 15:1 ratio in some crosses.

were both recessive, and both characters appeared in F_2 in the simple Mendelian ratio. The bulb in the second generation showed a great variety of shapes.

KAJANUS (247, 302, 498) made crosses between *B. Napus* and *B. rapa*. The results obtained are summarized in TABLE IV.

Bryonia dioica

JONES & RAYNER (450) published work on this plant. The following references are due to their work.

Bloom on the Berry. Absence of bloom (the berry looks scarlet) is almost completely dominant to its presence (the berry looks dull crimson), and is due to a single gene difference, **S** and **s**.

Number of Carpels. A cross between one variety in which most flowers are bicarpellary (as evidenced by the number of stigma-lobes and of placentae) and another variety in which most flowers are tricarpellary gave an intermediate condition in F_1 , and in F_2 almost every possible variation in the ratio of bicarpellary to tricarpellary flowers per plant. The results obtained were explained on the assumption of two genes **G**₁ and **G**₂, both increasing the percentage of bicarpellary ovaries per plant and having a cumulative effect.

Number of Vascular Bundles. The number of vascular bundles in a transverse section of the stem in one variety is typically 10, and in the other typically 14. The results from crossing showed that the capacity to increase the number of bundles beyond 10 behaves as a simple dominant to the absence of such capacity.

Foliage Characters. One variety has leaves dark-green in color, rough and deeply lobed, the other has the same paler, smoother and less deeply-lobed. In F_1 of the reciprocal crosses between these varieties the foliage was intermediate in character, with a bias towards the former type. In F_2 a number of new types due to the new combination of genes appeared.

Camelina sativa

TEDIN (1087, 1313) has published works on the inheritance of various characters in *C. sativa* and its varieties.

Leaf Shape. Two genes are concerned in the difference between pinnatifid and entire leaves. Thus :

- AB** pinnatifid,
Ab pinnatifid with shorter and broader lobes
 than the pinnatifid parent,
aB deeply dentate,
ab entire.

Hairiness. Three lines of hairy plants were crossed with one glabrous line. The results showed that these hairy lines differ respectively mono-, di- and trigenically for hairiness from the glabrous plant. No linkage between the genes for leaf shape and hairiness was found.

Height of Plants. Extensive investigations on the inheritance of height have been carried out. The results were explained on the basis of multiple genes. The two genes for leaf shape, **A** and **B**, were found to influence the height of the plant, **B** in less degree than **A**, **aa** plants being taller than **AA** plants, **bb** taller than **BB**.

Seed Color. The seed may be either yellow-brown or pure yellow. The difference was found to be due to a single gene, the yellow-brown being dominant.

Dwarfishness. A sterile dwarf plant which occurred as a mutant, was shown to differ monogenically from the normal plant. The heterozygote has a markedly different appearance from the normal.

Other Characters. The following characters were found to involve several multiple genes: the shape of the pod, the angle between the main axis of the inflorescence and the pod stalks, and the weight of seeds.

Campanula carpatica

PELLEW (509, 651) studied the inheritance of flower color and chlorophyll deficiencies in this species. The flower colors investigated were blue and white. The latter is a simple recessive to blue. The mode of inheritance, however, is peculiar, in that normal segregation of genes for blue and white occurs in the formation of ovules, but 97 per cent of the pollen-grains carry the gene for white and only 3 per cent the gene for blue.

There are many shades of blue, and in general the paler shades are recessive to the darker, but intermediate plants may throw slightly darker plants.

As to chlorophyll defects, the normal green type seemed to be dominant to white or patched seedlings.

Campanula medium

Floral Anomaly. The inheritance of a monstrosity—‘hose-in-hose’ or ‘cup-and-saucer’ Campanula—was studied by CORRENS (50). In this variation the petaloid calyx shows many gradations, varying from a condition in which the sepals are still partially green up to the full development of a second corolla. Such flowers are accompanied by a marked diminution in the fertility of the female organs. The abnormal character proved to be a partial and somewhat irregular dominant, considerable fluctuation occurring among individual plants.

Later LATHOUWERS (928) published some data on this problem. CORRENS’ observation on the diminution of the female fertility in this abnormal flower was not confirmed by him. In F_2 segregation was obtained in a typical 3:1 ratio. He assumed a single gene **C** for the calycanthemy.

Flower Color. In the same paper, LATHOUWERS reports that rose and white gave dark violet F_1 plants and in F_2 124 white-, 91 dark violet-, 30 violet-, 35 lilac-, and 11 rose-flowered individuals. These results were explained on the assumption of four genes. The formation of anthocyanin depends upon the co-operation of two genes, **A** and **R**. The third gene, **B**, was assumed to determine alkalinity and to be responsible for violet or dark violet instead of rose or lilac. The fourth gene, **V**, is an intensifier, converting violet into dark violet and rose into lilac. Thus the scheme of genes may be represented as:

VARB		dark violet,
VARb		lilac,
vARB		violet,
vARb		rose.

Other combinations lacking **A** or **R** result in white flowers.

Campanula persicifolia

BATESON (674) studied a dwarf form of this plant. The dwarf—about 8 inches high—is a plant so strikingly different from the normal type—2 or 3 feet high—that it is known among florists under a different name ‘*C. nitida*.’ The leaves of the dwarf are intense, dark green. This variety proved to be recessive to the normal type and to show segregation without any intermediate forms in a typical 3:1 ratio.

Canavalia ensiformis

LOCK (63) recognized the following allelomorphs in this plant :

- 1) Tall habit dominant to semi-dwarf ;
- 2) Pink color in the flowers dominant or nearly so to white ;
- 3) Absence of red pigment in the testa dominant to its presence.

In the last case, red reappeared in F_2 , but in nothing like its former intensity. Some of the plants of F_2 bore mottled seeds, but in these also the pigmented patches were of a very faint reddish color.

Canna

HONING (346, 407, 1026) working with *C. glauca* and *C. indica* reached the establishment of a number of genes as follows :¹⁾

A: a gene for red flower color, its absence resulting in yellow flowers.

B: in presence of **A**, gives broad red leaf margin, other combinations (**Ab**, **aB** and **ab**) resulting in green leaf.

C: a third gene for broad red leaf margin, plants possessing **C** but lacking both **A** and **B**, resulting in a very narrow red leaf margin. This gene is recognizable only in crosses of *C. indica* with its own green-leaved variety, and seems to be absent or totally incapable of manifesting itself in the cross with *C. glauca*.

D: } intensifiers for **A**, the red color gene; and also for **R**, the gene
E: }
F: } for patched staminodes.

E is coupled to a high degree with **B**.

G: an intensifier for red anthocyanin in the leaves. The F_1 plants of *glauca* $\times$ *indica* have much redder leaves than *indica*, depending on the gene **G**, cryptomeric in *glauca* and coupled with a gene for wax.

K: } polymeric genes for wax layer on the leaves of *glauca*.
L: }

M: }
N: } polymeric genes for the third staminode.
O: }

1) Vide an abstract in *Internat. Rev. Sci. & Pract. of Agr.* II. N. S. p. 83, 1924, in which the general results of HONING (1026) are summarized.

- Q:** a lethal gene in *glauca* $\times$ F_3^{10-3} , absolutely coupled with **A**, killing all **AA** plants in the offspring after selfing that hybrid. Probably it is the same gene that is coupled in *glauca* with **R** and when homozygous kills all **RR** plants.
- H:** } genes constituting together the difference between the deep
I: } yellow chromatophores in the staminodes of *indica* and the pale yellow ones in those of *glauca*.
- J:** a gene for deeper vein-coloring in most red flowered hybrids, almost invisible in the deep red flower, clearly visible in the pale ones. Perhaps the central red coloring of petals with a yellow margin is caused by the same gene.
- P:** an intensifier for the central coloring. **PP** and **Pp** plants have much narrower yellow staminode margin.
- R:** a gene for patches in yellow flowers. **RR** plants have patches spread over the whole breadth of the staminode, while in **Rr** plants such spots are in the middle of the staminode only. For this gene **R**, *glauca* is a constant heterozygote, owing to the presence of the lethal gene **Q** coupled with **R**.

Thus *C. indica* may be represented by

AABB(CC)DDFFggHHIIjjkkll(mmnnoo)ppqrrr,

and *glauca* by

aabb(cc)DdeeffG.hhiiJjKkL.(M.N.O.)PpQqRr,

in these genic compositions, doubtful genes being put in brackets and marked with a point, when, whether the character is in homo- or heterozygous condition, is unknown.

HONING also made observations on several other characters: leaf length and its breadth, staminode length and its breadth, form, size and color of the seeds, but a genic analysis on these characters was not worked out.

Cannabis sativa

FRUWIRTH (897), crossing light-seeded with dark-seeded varieties, obtained an intermediate F_1 and segregation of a 1:2:1 ratio in F_2 . Within each group, there were minor variations as to the intensity of color, indicating that other modifying genes are concerned.

Capsella Bursa-pastoris

Form of the Leaf. SHULL (82, 121, 202) described four biotypes of *C. Bursa-pastoris* which are distinguished from each other by certain

characteristic lobings of the leaves. They are called by the names heteris, tenuis, rhomboidea and simplex. The heteris has the leaves divided to the midrib, the terminal lobe being usually separated from the nearest lateral lobes by deep incisions. The lateral lobe consists of two portions, 'primary lobe', an elongated, attenuate portion and 'secondary lobe', a more or less rounded or angular portion in the distal axil of the primary lobe. In the tenuis, the terminal lobe is separated from the nearest lateral lobes by relatively shallow sinuses and moreover there is usually no 'secondary lobe'. The rhomboidea has the leaves divided to the midrib and possesses a more or less rhombic terminal lobe, separated by deep sinuses from the nearest lateral lobes. The lateral lobes usually show a prominent incision, corresponding to the secondary lobe of the heteris. The simplex resembles the tenuis in that the sinuses never reach the midrib, but it differs in having mostly simple rounded or triangular acutish lobes, not attenuate. There is no incisions in the lobes and hence no secondary lobing.

These four types were found to differ from each other by two gene pairs. In crosses, heteris $\times$ simplex and tenuis $\times$ rhomboidea, the F_1 plants are intermediate between heteris and rhomboidea, thus heteris showing an imperfect dominance, and in F_2 heteris, tenuis, rhomboidea and simplex appear in a ratio of 9:3:3:1. A gene **A** was assumed to produce elongated, sharp primary lobes and another gene **B** to divide the leaves to the midrib and originate the characteristic secondary lobing. Thus the genic scheme may be:

AB heteris,
Ab tenuis,
aB rhomboidea,
ab simplex.

In a later paper (583), he states that two genes, **B** and **B'** exist in certain strains and that these two genes produce the same characteristic lobing of the leaves, but are inherited independently of each other and of the gene **A**.

Besides these genes, Hus (347) found another gene **N**, responsible for the narrow character of the early leaves of certain forms, such as Setchelliana, Treleaseana, attenuata and arachnoidea. Absence of **N** results in the formation of early leaves of a 'broad' character. Homozygosity for this gene was found to result in total, or almost total, sterility.

Texture of the Leaf. SHULL (740), in F_3 of a cross between *C. Bursa-*

pastoris and *C. Heegeri*, found a small number of plants of unique type which has a more coriaceous texture than in the parents of either of the two original strains involved in the cross, and is also characterized by the lobing of the leaf much reduced and simplified and the angle of lobes almost spinescent. This new type was named coriacea. This variation proved to behave as a double recessive, being produced only when two genes **K** and **L** are absent.

Form of the Capsule. *C. Heegeri* differs in the shape of the capsules which are circular instead of flat and triangular (*Bursa-pastoris* type). SHULL (82, 121, 202, 368) found that the normal shape behaves as a dominant as regards the *Heegeri* type, giving in F_2 a ratio of 15:1. Two duplicate genes, **C** and **D**, were assumed, the absence of both resulting in the *Heegeri* type.

On the other hand, DAHLGREN (388) found a strain of *C. Bursa-pastoris* which behaves as a monogenic dominant over the *Heegeri* type. In later publications (615, 1123), he also reported some cases in which the normal strains were of the dimerous nature, like those of SHULL.

Abnormal Flowers. According to DAHLGREN (615, 1123), the decandrous form, viz., the flower with four petals transformed into stamens, behaves as a dominant (or prevailing) character over the normal. A single gene **E** was assumed.

Chlorophyll Deficiencies. CORRENS (612) found two types of chlorophyll defects in *C. Bursa-pastoris*. The chlorina race is a pale green type and behaves as a simple recessive to typica. The albovariabilis race is a white-variegated type and is also recessive to typica. In F_2 he obtained both 3:1 and 15:1 ratios. The cross, chlorina $\times$ albovariabilis, gave in F_1 typica, and in F_2 typica, chlorina and albovariabilis in an approximate ratio of 45:15:4. The results were explained on the assumption of four genes: **C** for chlorina, **T** for typica, **H₁** and **H₂** for homogenous distribution of chlorophyll.

The genic scheme may be represented as:

$$\begin{array}{ll}
 \left. \begin{array}{l} CTH_1H_2 \\ CTH_1h_2 \\ CTh_1H_2 \end{array} \right\} & \text{typica,} \\
 \left. \begin{array}{l} CtH_1H_2 \\ CtH_1h_2 \\ Cth_1H_2 \end{array} \right\} & \text{chlorina,} \\
 CTh_1h_2 & \text{albovariabilis (on typica-ground),} \\
 Cth_1h_2 & \text{albovariabilis (on chlorina-ground).}
 \end{array}$$

Sterility. SHULL (740) showed that a certain variety (East American biotype) has the lower flowers of the central axis nearly always completely sterile, while another variety (Pacific coast biotype) has no sterile flowers at the base of raceme. Crosses between these two types gave an F_1 partially sterile, with a rhythmic succession of fertile and sterile flowers. In F_2 about 1 in 16 resembled one parent, and a like number resembled the other parent, while the remainder again showed a rhythmic succession, thus suggesting the interaction of two genes.

Capsicum annuum

A summary of the inheritance of characters in the pepper is given below in a tabular form. (TABLE V).

Cardamine pratensis

Self-sterility. CORRENS (280, 434) found that self-sterility in *C. pratensis* is inherited in a definite fashion. The progeny of a cross between two self-sterile plants consists of four classes as to sterility, each of which includes almost equal numbers of individuals. Class I was fertile with both the parents, while Class II was sterile with one of the parents (G) but fertile with the other (B); Class III was sterile with B, but fertile with G, Class IV was sterile with both the parents. From these results, CORRENS assumed the existence of two genes, each of which inhibits the growth of pollen tubes from like gamete. The genes were designated as **G** and **B**. The four classes of F_1 from the cross $B \times G$ ($Bb \times gG$) may be represented as:

Class I = **bg**,

Class II = **bG**,

Class III = **Bg**,

Class IV = **BG**.

According to this assumption, plants of Classes II, III and IV should be self-sterile, while plants of Class I should be self-fertile. Plants **BG** should be fertile with plants **bg**, plants **Bg** should be fertile with **bG** and **bg**, and plants **bG** should be fertile with **Bg** and **bg**. But CORRENS' results were not completely in accord with the assumption.

Doubleness of Flowers. BLARINGHEM (871) reports that singleness behaves as a dominant over doubleness.

TABLE V.—A SUMMARY OF THE INHERITANCE IN *Capsicum annum*.

Contrasted characters	F ₁	F ₂	Authors
<i>Flower Color</i> Violet—white	Violet (considerably variable in the depth of color)	3 violet : 1 white	IKENO (299)
Violet flowers are accompanied by violet coloring in the leaf, stem and ripe fruit. White flowers only occur in the case of peppers with green leaves and stem, except for a dark spot near the attachment of the petiole.			
<i>Inflorescence</i> Umbel—non-umbel	Non-umbel	3 non-umbel : 1 umbel	IKENO (299)
<i>Fruit</i> Red—yellow or orange	Red	3 red : 1 yellow or orange	{ HALSTED (174) IKENO (299) WEBBER (270) ATKINS & SHERRAD (379)
Red—chocolate	Red	3 red : 1 chocolate	ATKINS & SHERRAD (379)
These colors of ripe fruit are due to red, chocolate, orange and yellow plastids.			
Yellow—green in unripe fruit	Green	3 green : 1 yellow	WEBBER (270)
In the yellow varieties the ovary from the bud to the time of ripening remains yellowish in color, developing no chlorophyll, while in the green varieties the ovary and young fruits up to the time of ripening are green, containing abundant chlorophyll in the cells of these parts. (WEBBER)			
Pointed—blunt apex	Intermediate	Nearly 3 blunt : 1 pointed (but several grades occurred)	WEBBER (270)
In another cross, however, the pointed condition seemed to be dominant.			
Large—small size	Intermediate	Continuous gradations between parental types.	{ IKENO (299) WEBBER (270) GROTH (400)
Pungent—sweet taste	Pungent	3 pungent : 1 sweet	{ HALSTED (174) WEBBER (270)
<i>Other Characters</i> Pubescent—glabrous stem and leaves	Less hairy than the hairy parent	15 pubescent : 1 glabrous	IKENO (299)
Erect—horizontal branches	Intermediate	Continuous gradations	WEBBER (270)
Large—small leaves	Intermediate	Continuous gradations	WEBBER (270)
Erect—recurved peduncle	Intermediate	1 erect : 2 intermediate : 1 recurved	IKENO (299)
IKENO reports that the F ₁ plants showed dominance of erect peduncle in the flower and young fruits.			
WEBBER had in one cross 31 erect, 48 recurved and 5 doubtful intermediate plants in F ₂ , and in another 21 recurved, 68 erect and 20 doubtful intermediate plants.			

Cattleya

HURST (116, 135, 296) states that the rosy-purple color in the flowers and leaves of the various species of *Cattleya* is due to the co-operation of two complementary genes, **C** and **R**. If **C** albinos are mated with **R** albinos, colored forms are produced. It was shown from the experimental results that *C. Mossiae Wageneri*, *C. Gaskelliana alba*, *C. × Hyeae Suzanne*, *C. intermedia alba*, *C. × Hyeae Jungfrau*, *C. × Mackayi Dusseldorfii*, *C. × Mackayi Undine* and *C. × Peetersiae Myra* may be regarded as **R** albinos, *C. × Peetersiae Myra* being a heterozygous **Rr**, the others being all homozygous **RR**. On the other hand, *C. Harrisoniana alba*, *C. Schroederiae alba*, *C. Warneri alba* and probably *C. Mendelii alba* may be regarded as **C** albinos, *C. Warneri alba* being a heterozygous **Cc**, the others being all homozygous **CC**.

Besides these true albinos, there exist so-called 'false albinos' (e. g. *C. Mossiae Reineckiana*), which behave as Mendelian recessives in crosses with full colored forms.

The yellow color of *C. Dowiana aurea* is completely recessive to the rosy-purple color of the Cattleyas, while the yellow colors of *Laelia Cowanii*, *L. flava* and *L. xanthiana* are dominant, though in most cases the dominance is incomplete.

Celosia cristata

TERASAWA (964) has published some data on this plant. A variety which possessed a mosaic red and yellow inflorescence, when selfed, gave a small proportion of red plants besides the parental type. In the next generation, these red plants gave a progeny consisting of 3 mosaic to 1 red plants, indicating that the difference between red and mosaic is monogenic. All these red plants showed, however, further segregation into the red (12%) and the mosaic. These results were explained on the assumption that the dominant condition of the gene is often changed into the recessive one and vice versa.

Centaurea scabiosa

HERIBERT-NILSSON (292). The red color in the flowers is a simple dominant to the white.

Cheiranthus cheiri

SIRKS (1214) worked with a variety known as *Ch. cheiri gynantherus*. In this variety, there are no stamens, but they are all replaced by 4 to 6 extra carpels surrounding the central ovaries (pistillody of the stamens), and also the petals are very small and calyx-like (sepalody of the petals). This abnormal form was pollinated by a pure breed yellowish brown-flowered variety. The F_1 plants were uniformly dark red and normal, indicating that the normal flower form is dominant to the gynantherous and further that the gynantherous parents carried a cryptomeric gene which converts the yellowish brown color into a dark red. In F_2 he obtained 358 normal and 50 gynantherous plants. As to the flower color, 3 pedigrees gave 210 dark red and 91 yellowish brown plants. The author considers these as 3 : 1 ratios modified by partial elimination of the weaker classes. The fourth pedigree gave a small number of light yellow (6) and yellowish violet (2) plants, in addition to dark red (37) and yellowish brown (12) individuals. These results were explained on a 3-gene assumption : **N** for normal flowers, **S** for dark red flowers and **G** for yellowish brown flowers.

Thus :

NSG	}	 dark red,
NSg		
NsG		yellowish brown,
Nsg		light yellow or yellowish violet,
n(SG)		gynantherous.

Chelidonium majus

According to DE VRIES (8, 13, 56) and DAHLGREN (536), the laciniated leaf-form behaves as a simple Mendelian recessive to the normal one.

The latter author and SAX (581) studied the inheritance of doubleness of flowers. They recognized dominance of singleness, doubleness (owing to petalody) appearing to be a simple Mendelian recessive character. SAX states that there is apparently a continuous series in degree of doubling from singles to full doubles in F_2 .

Chrysanthemum Roxburghi

DE VRIES (8). The yellow pigment in the flowers is dominant to the white.

Clarkia elegans

BATESON (106) states that common magenta-red flowers are dominant to salmon-pink.

RASMUSON (734) studied several color varieties: purple ('lila'), purplish-red ('lilarot'), salmon-red ('lachsrot'), light red ('hellrot') and white. The cross, white $\times$ salmon-red, gave in F_2 a segregation of 15 colored : 1 white; and white $\times$ purple gave in F_2 9 purples : 3 light reds : 4 whites. The order of dominancy was found to be: purplish-red—salmon-red—light red—white. The results were explained on the assumption of four color genes (A, B, C and D).

Clarkia pulchella

DE VRIES (8, 56) mentions that the pigmented type is dominant to the white.

RASMUSON (734) working with purple ('lila'), purplish-red ('rote lila'), white, and purple with white margin ('lila mit weissem Rand') found that uniform colored flowers are dominant to those with white margin, colored to white, and also purple to purplish-red. In each case, a single gene was found to be concerned. Three genes (A, B and C) were assumed for interpretation of the results obtained.

Clitoria ternata

RANT (948) studied the inheritance of color and form of the flower. Two allelomorphic pairs of characters were studied.

- 1) Blue—white flowers,
- 2) Peloric—non-peloric flowers.

In both cases, the first given members were dominant. Some crosses between dark blue and white gave in F_2 violet-flowered plants. The analysis of the violet color has not been completely carried out.

Collinsia bicolor

RASMUSON (733) crossed a white-flowered variety (alba) with the normal type, the flowers of which are lilac at the lower lip and whitish at the upper lip. The F_1 plants were lilac and in F_2 segregation occurred in a ratio of 9 lilac : 7 white. The lilac-flowered plants always had red stems; the white-flowered plants had either green stems or those

slightly tinged with red at the base and also at the nodes. Thus the segregation as to stem color followed the theoretical ratio of 9 red : 3 slightly tinged with red : 4 green. The results were explained on the digenic basis, **A** producing white flowers and red-tinged stems, and **B** producing white flowers and green stems. When both **A** and **B** are present, the flowers are lilac, and the stems red. The absence of both the genes results in white flowers and green stems.

Collinsia tinctoria

RASMUSON (733) studied the inheritance of spots on the flower and variegation in this plant. He found that the presence of spots on the upper lip of the flower is a character monogenically dominant to its absence.

He also found a plant, in which the leaves were not self-green, but had yellow spots and stripes. This plant crossed with the self-colored type, gave 3 self-colored to 1 variegated in F_2 . One-fourth of the variegated plants were yellow and non-viable. A gene, **I**, was supposed which increases the amount of green in variegated plants. The yellow were assumed to be **ii**.

Corchorus capsularis

FINLOW & BURKILL (231) reports that the possession of red pigment in the vegetative parts behaves as a simple Mendelian dominant over its absence. There are various grades of pigmentation, and these are classified into three groups as follows:

- 1) Red stems with red petioles and fruits ;
- 2) Light red stems, petioles and fruits ;
- 3) Green stems with reddish petioles and fruits.

But they have not been genetically analysed. In the absence of the red pigment the plants are pure green.

Coreopsis tinctoria

DE VRIES (8). Ordinary yellow-flowered type is dominant to var. *brunnea* with brown flowers. The type is considered to contain an inhibitor of anthocyanin.

Crepis capillaris

BABCOCK & COLLINS (867, 868) and especially the latter alone (1120)

have investigated the inheritance of several characters in *C. capillaris*. The results obtained are briefly given below.

Pubescence. 'Bald'. A form lacking normal glandular pubescence on involucre bracts and pedicels was named 'bald'. Bald is inherited as a simple monohybrid recessive to the normal condition. Bald is also recessive in the species-cross, *setosa* × *capillaris*. Gene **b**.

'Smooth midribs'. In most varieties the midribs of the rosette leaves have a hairy pubescence. Races devoid of these rib hairs were found and named 'smooth'. Pubescent × smooth gave pubescent F_1 plants, and F_2 conformed to ratio pubescent : non-pubescent = 15 : 1, suggesting the existence of two independent duplicate genes, **s** and **s'**.

Form of the Leaf. 'Scalaris'. This form is characterized chiefly by long, simple, pinnately-divided rosette leaves with pointed lobes. The terminal lobe is slender and elongated, often curved to one side near the tip. This form is dominant to entire leaf forms. In F_2 a monogenic ratio was obtained. Gene **sc**.

COLLINS made a cross between two of the pinnatifid races which originated from different sources. The results obtained were briefly listed as follows :

Characters	Type I	Type II	F_1	F_2
Crimping of rib-wing	pronounced	none	pronounced	9:7
Lobe	broad	narrow	narrow	9:7
Lobe	rounded	angular	angular	9:7
Constricted base of lobes	pronounced	none or trace	pronounced	9:7

'Revolute'. The plants are characterized by a definite downward curling of the margin of the leaf toward the midrib. Revoluteness is conditioned by complementary recessive genes, **r** and **r'**.

Growth Habit. 'Dwarf'. The plants are characterized by a very small rosette of slender semi-scalaris leaves which are blotched with yellow and yellowish red coloration, giving them the appearance of being about half-dead. This form proved to be recessive. The data obtained suggested that there might be duplicate genes for the dwarf type. Another dwarf type, which shows high mortality, a large percentage dying before the flowering stage, proved to be also recessive to the normal type. In one culture, the ratio of normals to dwarfs was 15 : 1 ; in another 3 : 1. The genes have not been designated.

'Spreading'. A lax, open-branching habit was a recessive character

to the erect type in some cases. Gene **sp**. In other cases, however, it behaved as a dominant.

'Procumbent'. This variation is similar in appearance to 'spreading'. Erect $\times$ procumbent gave procumbent F_1 plants. In F_2 accurate classification of individuals was difficult. Gene **p**.

'Erect'. This is a strain characterized by erect habit of growth, large stiff lateral branches and a thick rigid central axis. The branches make an acute angle with the axis, the whole plant being in the form of an inverted cone. In crosses with the spreading type, it behaved sometimes as a recessive. Gene **e**.

Chlorophyll Deficiencies. 'Chlorina'. This form is characterized by a chlorophyll deficiency in both seedling and mature stages, in which the middle portion of the leaves is yellowish. Chlorina $\times$ green gave chlorina and green plants in a 1:1 ratio, thus showing that chlorina plants were heterozygous for green. The seedling progeny from self-fertilized chlorina plants consisted of pure yellow, pale green and normal green in a ratio of 1:2:1. The yellow seedlings die; the pale green develop into chlorina plants. It is evident that the gene for chlorina has a lethal action when homozygous. Gene **c**.

'Golden yellow'. The seedlings gradually develop chlorophyll and finally reach maturity, although growing much more slowly than their green sibs. In some progenies segregation of golden yellow was monogenic, while in others the ratio of normal green to yellow was 15:1, in still others 9:7.

'Virescent yellow'. This seedling type has a small amount of green color in addition to the yellow. It is dominant to yellow but recessive to green.

Anomalies. 'Bicephalic'. This character designates a type of fasciation in which the buds are more or less jointed together in twos. The peduncle is also frequently flattened. Bicephalic is a simple recessive to normal. Gene **bi**.

'Palea'. The plants have foliaceous palea-like bracts subtending the achenes on the receptacle of every capitulum. This occurred in every case in hybrids, never in inbred races, and was considered to be a reversion to a pre-composite type of inflorescence (COLLINS, 770). Palea is inherited as a recessive to the normal type. Gene **p**.

Color. The anthocyanin distribution is most noticeable in the midribs of the leaves and on the lower portions of the stems. Crosses between intense and light anthocyanin races in general produced F_1

plants showing the darker anthocyanin and in F_2 produced a series of forms showing a gradation in pigment from one parent to the other. In some cultures the segregation occurred in a 3 : 1 or 9 : 7 ratio. But since development of anthocyanin is much influenced by environmental conditions, analysis regarding its genic composition was not quite satisfactory.

On the other hand, RAU (1069) also studied the inheritance of some morphological characters in *C. capillaris*. The results were as follows :

Length of the Leaf. Crosses were made between one strain with a range of from 13 to 23 cm., and another with a spread of 21.0 to 40.1 cm. In F_2 a distinct segregation occurred, but owing to the effect of environmental conditions it was not possible to determine the number of genes involved.

Size of Capitulum. Two strains were crossed, one having a diameter ranging from 17 to 25 mm., and the other from 21 to 36 mm. The F_1 was intermediate, but closer to the smaller parent.

Besides these characters, the number of lobes was also investigated. But no definite result was obtained.

Linkage Relations. COLLINS (1120) found that independent inheritance was shown in the following pairs of characters :

- 1) bald involucre—smooth ribs,
- 2) bald involucre—procumbent.

From the point of view that linkage must occur between one pair of complementary genes for smooth ribs and one pair of complementary genes for revolute leaves, since there are four pairs of genes and only three pairs of chromosomes, he made crosses smooth $\times$ revolute and obtained the following results in F_2 :

Ribs :	pubescent	pubescent	smooth	smooth
Leaves :	flat	revolute	flat	revolute
Observed :	202	16	32	2
Calculated :	224	11.79	11.79	3.93
(57: 3: 3: 1)				

From these results, it was concluded that the genes **R'** and **S'** are partially linked, the four genes being arranged in the three pairs of chromosomes as follows : **R, r—(R' S'), (r' s')—S, s.**

Cucumis melo

LUMSDEN (358) has published a contribution on the muskmelon.

The results obtained showed that the following pairs of characters differ monogenically from one another, the first given members being dominant:

- 1) Color of skin : yellow vs. green,
- 2) Form of fruit : round vs. elliptical,
- 3) Size of fruit : large vs. small,
- 4) Size of seed : large vs. small.

The other characters investigated were netting and ribbing, which indicated more complex inheritance. *Delices de la table* (♂) has deep ribbing and no netting; *Sutton's Superlative* (♀) has pronounced netting but no ribbing. The F_1 fruit was recorded as ribbed and netted. In F_2 a considerable variation of from 5 to 100 per cent was shown with respect to each character. The actual data obtained in F_2 were (5–45% ribbing) : (46–100% ribbing) = 1 : 1.82 and (5–45% netting) : (46–100% netting) = 1 : 1.63.

Later McCLELLAND *et al* (815), working with the cross between a large native muskmelon and two commercial varieties, found that netting was practically recessive, only a trace being observed about the peduncular end of the F_1 fruit. They reported also that the time of ripening was inherited in F_1 as an intermediate character.

As to the inheritance of rust-resistance, ORTON (98, 192) states that the wilt-resistance is a dominant character against susceptibility, while McCLELLAND *et al* obtained some results indicating that mildew-resistance is not a dominant character, F_1 showing no indication of the mildew-resistant character.

Cucumis sativus

According to HAYES & GARBER (792), WELLINGTON ('13) obtained ratios indicating monohybrid segregation in the following characters of the fruit : color, size, number of spines, smooth or rough skin. Smooth skin and small spines, few in number, appeared to be linked.

Cucurbita maxima

LORSY (720) studied the inheritance in the Large field squash. A cross, *Turban Pumpkin* (♀) × *Hubbard's Green Pumpkin* (♂), gave red F_1 fruit and showed in F_2 a monogenic segregation of 3 red : 1 green. None of the F_2 fruits was, however, entirely red; there was always some

green tint about them, at least at the extremity. Another cross, Turban Pumpkin (♀) × Silver-gray Pumpkin (♂), gave also red fruit in F_1 . In F_2 , however, a considerable variation occurred: red, pink, flesh-colored, pale yellow, dark yellow, white, dark red, light red, gray and other colored fruit. The results showed that red is the most epistatic color and gray is dominant to brown and green.

Lotsy also made some observations on fruit-surface characters. The cross, Turban Pumpkin × Hubbard's Green Pumpkin gave the F_2 plants, of which there occurred a few plants with smooth fruit having no trace of groove or cap. This gave the ratio 15:1, suggesting that the groove or cap depends upon the presence of two genes.

Cucurbita pepo

Drude (538) and Lotsy (720) have made extensive crosses among forms of *C. pepo*. They showed that in certain cases reciprocal crosses yield dissimilar results. Sinnott & Durham (957), working with several pure lines, however, denied this statement, showing that the results of reciprocal crosses are essentially similar. Several characters were analyzed by Sinnott & Durham. A summary of their results is given below in TABLE VI.

Cypripedilum (Paphiopedilum)

Hurst (40, 116, 135, 296) found rose-purple pigment dominating over its absence in the flowers and leaves. Two albinos when crossed often gave colored offsprings. The formation of sap-color was considered to depend on the simultaneous presence of two complementary genes, **C** and **R**. Crossing results showed that *C. callosum* Sanderæ, *C. Lawrenceanum* Hyeænum, *C. × Maudiae*, *C. insigne* Sanderianum and *C. × Rosettii* may be regarded as **R** albinos, while on the other hand, *C. bellatulum album* may be regarded as **C** albino.

Besides these genes, there is another color gene, the absence of which causes dilute colored types, so-called 'false albinos', e. g. *C. insigne* Sanderæ, *C. Lawrenceanum* Gratrixianum.

Datura

De Vries (8, 56) made some observations on the inheritance of flower and fruit characters in *Datura* crosses. Bateson & Saunders (15, 47) employed the following forms for crossing:

TABLE VI.—INHERITANCE IN *Cucurbita pepo*.

From the data obtained by SINNOTT & DURHAM (957).

Contrasted characters	F ₁	F ₂
<i>Body Color of Fruit</i>		
The colors of the fruit body of squashes may be divided into three main groups: white, yellow and green, though in each of these considerable variations are observable.		
White—yellow	White	3 white : 1 yellow ¹⁾
Yellow—green	Yellow	3 yellow : 1 green
White—green	White	12 white : 3 yellow : 1 green
The color varieties were represented as: WY or Wy =white, wY =yellow, wy =green. In some cases, white × yellow gave a great preponderance of white in F ₂ , suggesting a 15:1 ratio. The gene W may be split into two elementary genes W₁ and W₂ . Besides these main genes there may be various modifying genes.		
<i>Striping of Fruit</i>		
There are three types of striping: yellow-striped white, green-striped white and green-striped yellow.		
Plain white—green-striped white	Plain white	(43) plain white : (9) green-striped white
Plain yellow—yellow-striped white	Yellow-striped white	Complex segregation
It is evident that plain white is dominant to striping, a single gene difference being involved. The relation between striping and plain yellow, however, is not entirely clear.		
<i>Flesh Color of Fruit</i>		
White—cream (White squash)	White	3 white : 1 cream
In cases, where a yellow squash was used as the cream fleshed parent, the F ₁ was white with a very slight creamy tint, and in F ₂ white and cream appeared in a 1:1 ratio.		
<i>Surface of Fruit</i>		
Smooth—moderately warty	Warty	3 warty : 1 smooth
Smooth—extremely warty	Warty	15 warty : 1 smooth
It seems that wartiness is caused by two independent genes cumulative in their effect.		

1) Also BECKER (870).

Contrasted characters	F ₁	F ₂
<i>Fruit Shape</i> Disc—sphere	Disc	3 disc : 1 sphere ¹⁾
There may be, however, another gene, also dominant, but showing much smaller effect than the first.		
<i>Flower Scars</i>		
Two types of the scars at the fruit tip were studied: single and double. In the former, the scars of the stigma and of the corolla are united, whereas in the latter they are separated by an area of smooth pericarp.		
Single—double	Single	Segregation in singles and doubles in variable proportions, usually with a great preponderance of singles
<i>Habit of Vine</i> Runner—bush	Intermediate	Segregation with a marked preponderance of bush plants

D. Stramonium = stems green, flowers white, fruit prickly.

D. Stramonium var. *inermis* = stems green, flowers white, fruit smooth.

D. Tatula = stems reddish, flowers violet, fruit prickly.

D. Tatula var. *inermis* = stems reddish, flowers violet, fruit smooth.

Reciprocal crosses between these different types showed clearly that the following pairs of characters differ from one another by a single gene:

- 1) Flower: violet vs. white,
- 2) Stem: reddish vs. green,
- 3) Fruit: armed vs. smooth.

In the above, the first given members are dominant. A similar result was later obtained by BLAKESLEE & AVERY (483, 604) and SAFFORD (837). The former investigators found also that 'many nodes' causing tall stature is a simple dominant to few nodes' causing low stature.

Daucus Carota sativa

HOLTERMEISTER ('08, cited by TSCHERMAK, 475), working with natural

1) Also SINNOTT (956). In a later paper (1079), SINNOTT reports that crosses between crookneck and disc or sphere gave in F₁ intermediate forms and in F₂ complex segregations. BECKER showed long forms to be monogenically dominant to short forms.

hybrids of carrots, found that white skin color is dominant to yellowish red and the large root form of the giant carrot to the short, thick form of the garden carrot.

Delphinium consolida

HURST (177) gives a brief list of characters subject to Mendel's law in this plant as follows :

Single, and semi-double flowers.

Blue, pink and white flowers.

Dendrobium

HURST (135, 296) found a purple pigment in the flower dominant to its absence (albino). As in other orchids, the albinos in *Dendrobium* may be divided into two classes—C albinos and R albinos. *D. nobile virginale* has the genic composition **ccRR**, and *D. Wardianum album* **CCrr**.

Dianthus barbatus

LILIENFELDÓWNA (933, 1187) made detailed studies on the inheritance of several characters of this plant. The following description is given after his work.

Flower Color. Some strains of colored plants change their flower colors during a lifetime; white-flowered young plants later bear red or violet flowers. Such forms were named 'versicolor.' The results from crossing showed that :

- 1) 'Versicolor' (**M**) is dominant to non-versicolor (**m**);
- 2) In the non-versicolor group, violet (**V**) of the ring markings is dominant to red (**v**);
- 3) In the versicolor group, red 'Endfarbe' (**R**) is dominant to violet (**r**);
- 4) Netting (**N₁**) on the petals is dominant to its absence (**n₁**).

It was found that there is a complete correlation between netting and hairing on the petals. The author considers that both characters are the result of a single gene, **N₁**, and not due to complete linkage between two genes. The effect of this gene is heterozygously weakened. There is another netting gene, **N₂**, which is effective only in the presence of **N₁** and originates the netting, characteristic for single flowered 'versicolor' plants. The **N₁N₁n₂n₂** plants show a weak netting seen in double flowers.

Doubleness of Flowers. In the double variety, the stamens take the forms of petals. Singleness was found to be a simple dominant to doubleness, confirming the result obtained by SAUNDERS (511).

Growth Habit. A gigas form was found which differs from the normal plant in being larger, especially in regard to thickness of stem and leaves. An anatomical study showed that the tissues give the impression of pathological hypertrophy. Another noteworthy characteristic of the gigas form is the spiral tendency ('Zwangsdrehung'). The progeny from this plant, consisting of 105 plants, showed in 103 of them the gigas character. The gigas form proved to have the genic constitution of **mmEE**. (See also under '*Linkage Relations*.')

It was also found that the normal growth is dominant to dwarfishness, depending on a single gene.

Chlorophyll Deficiencies. Several chlorophyll defects were found by him: albino, chlorotica, hemi-chlorotica, chlorina and semi-chlorina. The following results were recorded:

- 1) The albino races showed segregation in 3 typica : 1 albino,
- 2) The chlorotic races in 3 typica : 1 chlorotica, or in 9 : 7,
- 3) The hemi-chlorotic races in 79 typica, 20 hemi-chlorotica and 5 albino,
- 4) The chlorina races in 3 typica : 1 chlorina,
- 5) The semi-chlorina races in 3 typica : 1 semi-chlorina.

*Linkage Relations.*¹⁾ We have three linkage groups at present: I, a linkage between versicolor (**M**) which is absolutely coupled with **N₂** and single flower (**E**), with the gametic ratio of 18 : 1; II, that between hairiness (**N₁**) and red 'Endfarbe' (**R**); and III, that between normal growth (**L**) and violet color of the ring markings (**V**); the number of observations, however, was still too small to determine their linkage values.

Dianthus Caryophyllus

Flower Color. In crossing a yellow carnation (James Whitcomb Riley) with a white variety (White Perfection), CONNORS (337) found that in the latter parent red was present as a latent character. The results showed that white is dominant to yellow and red, and in **F₂** yellow is dominant to red. In some yellow carnations, the presence of

1) The haploid chromosome number in *Dianthus barbatus* is 15. (Vide BLACKBURN'S paper in *Zts. Ind. Abst.- u. Vererbgs.* Supplem. Band I. 1928.)

red was found to be associated with the perfect sexual organs. Somewhat uncertain as the basis was, he nevertheless formulated the scheme of genes as: **W(YR)**=white, **wY(R)**=yellow, **wyR**=red, **wyr**=??? (either white, red or dilution).

Doubleness of Flowers. The single carnation has, as a rule, five petals. The commercial standard double type has from 30 to 60 petals, varying among the varieties. The bullhead is the extreme double form, in which the number of petals ranges from 100 to 350. BATCHELER (215) found that the difference between the single form and the bullhead type is monogenic, the heterozygotes being the standard type. A similar result was obtained later by SAUNDERS (511).

Digitalis gloxiniaeflora

WARREN (426) showed that the non-peloric form is dominant to peloric, purple in the corolla to white, and purple spots on the corolla to brown spots.

Digitalis purpurea

Flower Color. KEEBLE, PELLEW & JONES (138) found that foxglove contains a dominant white gene. According to them, there are three genes concerned in the color of the flower, **M** producing magenta, **D** changing magenta to purple, and **W** inhibiting the color. As to the color of spots on the corolla, they showed that in the presence of **M**, the spots are red, while in its absence they are yellowish brown. The presence of the dominant white gene **W** does not inhibit the expression of the **M** gene in regard to the spots (at least when present as a heterozygote **Ww**). A scheme of the genes may be represented as :

WM(D)		white with red spots,
Wm(D)	}	 white with yellow spots,
wm(D)		
wMD		purple with red spots,
wMd		magenta with red spots.

SAUNDERS (201) reached a similar conclusion on the inheritance of spot color. White-flowered plant with red spots were found either to breed true, or give a mixture of white with red spots and white with greenish-yellow spots.

On the other hand, MIYAKE & IMAI (650, 724) obtained no dom-

inant white flowers; white-flowered plants with red spots proved to be recessive. According to them the inheritance of flower color can be represented by the following scheme :

CP red with red spots,
 Cp white with red spots,
 c(P) white with yellow spots.

Stem Color. According to MIYAKE & IMAI (650, 724), purple-stemmed plants produce either purple flowers or white flowers with red spots, while green plants have always white flowers with yellow spots. Purpleness of stem was found to be dominant to green, giving segregation in F_2 in a 3:1 ratio. It was assumed that the gene C produces pigments in stems, petioles and flowers.

Type of the Flower. That the peloric condition of the flower behaves as a simple recessive character to the normal non-peloric condition has been reported by KEEBLE, PELLEW & JONES (138), SAUNDERS (201), and MIYAKE & IMAI (650).

SAUNDERS also showed that heptandry is similarly recessive to the normal. This was confirmed later by SHULL (264).

Pubescence. With respect to the type of pubescence, there are two varieties; one having the whole length of the stem covered with hairs, the other having the lower part of the stem quite glabrous (*nudicaulis*). SAUNDERS (201, 580) reports that the partially glabrous type is a monogenically dominant to the completely hairy type, a conclusion confirmed by MIYAKE & IMAI (650, 724).

Dolichos lablab

HARLAND (700) has published a contribution on this plant. The following is an abstract of his work.

As to pigmentation, intimate connection was found between colors in the flower, seed coat and plant body. The varieties studied may be classified as follows :

- 1) Purple flowers, black seeds and purple nodes.
- 2) White flowers, purplish brown seeds and purple stipular hairs.
- 3) White flowers, white seeds and green plant body.

A cross between two white-flowered varieties, (2) $\times$ (3), gave a purple-flowered (1). In F_2 these three classes appeared in a 9:3:4 ratio. The results were explained on the assumption of two genes : C for purplish brown seed coat and purple stipular hairs, and R, together with C, con-

verting white flowers into purple, brown seed into black and also causing pigmentation of the nodal regions.

With respect to the inheritance of habit of growth, the indeterminate (climbing) habit was found to be a dominant character against the determinate (dwarf or bush), and the segregation was normal.

Dracocephalum thymiflorum

DAHLGREN (1123) made a cross between *D. thymiflorum typica* and *D. thymiflorum* var. *pallida*. The type is blue-flowered and is rich in anthocyanin in its vegetative parts; the variety is entirely devoid of anthocyanin, and has white flowers. The difference between the two forms was found to be monogenic, the colored form being dominant.

Epilobium angustifolium

CORRENS (2, 3). The red-flowered type (with grayish green pollen grains) is dominant to the white-flowered variety (with white pollen grains), and a monogenic ratio was got in F_2 .

Epilobium hirsutum

STOMPS (315). The cruciata variety in which the petals are small, linear and greenish (sepalody), is recessive to the normal-flowered type, giving a monogenic ratio in F_2 .

Eschscholtzia mexicana

UPHOF (970) found the following pairs of flower colors to be monogenically different from one another, the first given members being dominant:

- 1) White—yellow,
- 2) White—orange,
- 3) Orange—yellow with orange base of petals.

There are two genes for the orange color, one distributing the color over the entire petals, the other manifesting itself only at the base of petals.

Fagopyrum

CORRENS (772) and DAHLGREN (887, 1123) working with *F. esculen-*

tum and *F. emarginatum* studied the inheritance of heterostylism. It was found that long-styled plants are homozygous (**aa**) and give by self-fertilization only long-styled individuals, while short-styled (**Aa**) yield plants of both kinds. Short-stylity is considered to be dominant to long-stylity.

Fragaria

Our knowledge as regards the inheritance of various characters in this genus is due to the work of RICHARDSON (365, 579, 737, 1070).

Flower Color. The cross with *F. vesca*, pink $\times$ white gave pink in F_1 , and in F_2 77 pink or pale pink and 10 white or very nearly white (of the latter at least 3 were absolutely white). It was difficult to distinguish between very light pinks and pure whites. The ratio of colored to white was considered to be 15 : 1.

Fruit Color. In *F. vesca*, the difference between red and white was found to be monogenic, the red color being dominant. Red is also dominant to dark red (so-called black) and light red, both being dominant to white. The crossing of light red with dark red has not yet been carried out.

Double Flower. In *F. vesca*, the cross, double $\times$ single, produced in F_1 single flowers with occasional extra petals. In F_2 doubles and singles appeared in a 3 : 1 ratio.

Habit of Growth. Runnerless strains of *F. vesca* crossed with runnered forms gave runner-producing plants in F_1 and both types in F_2 . The data suggest a 3 : 1 ratio on the average, but there was a great discrepancy between the various pedigrees.

Leaf Type. In *F. vesca*, the cross between normal trifoliolate and abnormal monophylla (i.e. type with simple leaves) gave trifoliolate in F_1 and 177 trifoliolate to 73 monophylla in F_2 .

Pubescence. In reality all varieties of *Fragaria* have stems hairy to some extent, but some appear to be 'hairy' because the hairs stand out from the stems and are more numerous. On the other hand, the front of the leaf may be quite glabrous. A cross between *F. virginiana* and *F. chiloensis* gave in F_1 'hairy' stems and leaf front, and in F_2 3 'hairy' stems to 1 'hairless' stems, the former having also hairy front of the leaf, while the latter being quite glabrous.

Perpetuals. The perpetual habit, i.e. the habit of flowering and fruiting more than once in a season was found to be inherited. Two garden varieties, St. Antoine de Padoue and Laxton's Perpetuals, when

selfed, gave perpetuals and non-perpetuals in a ratio close to 3 : 1. But crosses of a garden variety, Bedford Champion (non-perpetuals) with Laxton Perpetual gave an inexplicable result: 24 perpetuals and 53 non-perpetuals.

RICHARDSON noted also the inheritance of form and texture of leaf, variegation, fruit-flavor, size of fruit, sterility and fertility, and sex in certain crosses.

Galeopsis tetrahit

HAMMERLUND (1259) records the F_2 generation of a spontaneous cross between two plants, one susceptible, the other immune to mildew, *Erysiphe Labiatrum*. The immunity proved to be a simple recessive. The gene **M** was assumed to act against the production of tannin which is very poisonous to parasitic fungi. The mildew was found to show weaker vitality upon the heterozygotes than upon the homozygous **MM** plants.

Geranium robertianum

DAHLGREN (1123) states that the common red flower color is dominant to the white (*f. leucanthum*) and the segregation is normal.

Gerbera

HURST (176) briefly states that red and yellow flowers are simple (?) Mendelian characters.

Geum

ROSÉN (463) and WEISS & ROSÉN (1229) made some observations on the species hybrid, *G. urbanum* ♀ × *G. rivale* ♂. Several character pairs distinguishing these two species were taken into consideration. The main results obtained are briefly given in TABLE VII.

DAHLGREN (1123) made a cross of *G. rivale* with *G. pallidum* which lacks anthocyanin, and obtained a monohybrid ratio in F_2 , the presence of anthocyanin being dominant.

Glycine Soja

Seed Coat Color and Pattern. As regards seed coat color, TERA0

TABLE VII.—INHERITANCE IN *Geum urbanum* × *G. rivale*.

<i>G. urbanum</i>	<i>G. rivale</i>	F ₁	F ₂
<i>Size of Stipules</i>			
Large	Small	Large	Segregation (multiple genes)
<i>Height of Stem</i>			
40 cm.	35 cm.	50–60 cm.	Segregation (10–60 cm.; multiple genes)
<i>Inclination of Peduncle</i>			
Erect	Recurved	Recurved	(4) erect : (204) more or less recurved. (3 genes)
<i>Size of Flowers</i>			
Large	Small	Large	Segregation (multiple genes)
<i>Color of Flowers</i>			
Yellow	Non-yellow	Yellow	3 yellow : 1 non-yellow
Non-red	Red	Red ¹⁾	No segregation ; several intensities of red. (A number of genes.)
<i>Color of Stem</i>			
Green	Brown	Brown	6 brown : 1 green (2 duplicate genes, B and C ; the original cross bbcc × BBCc .)
<i>Margin of Petals</i>			
Sinuate	Entire	Entire	3 entire : 1 sinuate
<i>Color of Calyx</i>			
Green	Brown	Brown	No segregation. (A number of genes.)

(590) reports that in the cross 'green cotyledons, green-seeded coat (♀)' × 'yellow cotyledons, yellow-seeded coat (♂)', the green seed coat is inherited exclusively through the female parent ; but in the reciprocal cross the green and yellow seed coats show Mendelian segregation, the former being dominant.

1) In the F₁ hybrids, the petals are yellow on their inner and red on their outer surfaces, partaking of the character of both parents.

On the other hand, WOODWORTH (859) denied this statement, and showed that green $\times$ yellow as well as the reciprocal cross gave in F_1 only green-seeded plants, and in F_2 3 green : 1 yellow.

For other colors, PIPER & MORSE (139) have recognized in natural hybrids the following pairs of colors to be monogenically different from one another, the first given members being dominant to the latter :

- 1) Dark brown—light brown,
- 2) Black—brown,
- 3) Green—black,
- 4) Black with brown spots—uniform black,
- 5) Brown—yellow ?

Thus the common green variety seems to contain an inhibitor, suppressing the formation of the chromogenic substances which give rise to other colors by the action of certain complementary genes.

TAKAHASHI & FUKUYAMA (1333) tried a number of crosses, in which pale yellow proved dominant to reddish brown, green to pale yellow, and pale green to reddish brown. Certain crosses gave more complicated results ; e. g., pale yellow $\times$ black gave in F_1 pale yellowish green and in F_2 several phenotypes : green, pale green, pale yellow, black, brown and reddish brown ; another cross, black $\times$ green, gave in F_1 pale yellowish green, and in F_2 pale green, green, reddish brown and black.

Later NAGAI (822) made several crosses, the main results of which are as follows :

1) Blue tinged yellow $\times$ brown $\rightarrow F_1$, blue tinged green $\rightarrow F_2$, 9 blue tinged (3 green : 1 yellow) : 3 non-tinged (3 green : 1 yellow) : 3 black : 1 brown.

2) Buff $\times$ black $\rightarrow F_1$, black $\rightarrow F_2$, 9 black : 3 imperfect black¹⁾ : 3 brown : 1 buff.

3) Reddish brown $\times$ lighter brown $\rightarrow F_1$, lighter brown $\rightarrow F_2$; 3 lighter brown : 1 reddish brown.

4) Yellow $\times$ reddish brown $\rightarrow F_1$, yellow $\rightarrow F_2$, 36 green : 12 yellow : 12 black : 3 brown : 1 reddish brown.

Hence the different color types may form the following series when they are arranged in order of dominancy :

blue tinged green—blue tinged yellow—green—yellow—black—imperfect black—lighter brown—deeper brown—buff.

1) 'Imperfect black' is characterized by the incomplete development of the pigment.

For interpretation of these results, the author (also 1060, 1201) has assumed the following genes :

- G** : a gene for green, its absence (**g**) resulting in yellow.
- C** : a gene for the chromogenic substance ; its absence (**c**) acts like **C** to a slight extent.
- O** : converts the chromogenic substance into brown pigment ; **o** into reddish brown.
- R** : converts the chromogenic substance into black pigment ; **r** has no effect.
- I** : inhibits nearly completely the formation of the chromogenic substance ; **i** has no effect.

With respect to color pattern, WOODWORTH (859) has recognized the dominance of black hilum ('eye') over brown hilum, followed by a F_2 segregation of 9 black to 7 brown.

TAKAHASHI & FUKUYAMA (1333), working with several hilum colors, such as black, brown, green and pale yellow, found the black color to be most epistatic to the others and also brown dominant to pale yellow. The genic analysis, however, has not been completed.

According to NAGAI & SAITÔ (1060) and NAGAI (1201), these black or brown eyed types are dominant to full colored ones, except to full green and yellow which prove dominant to the 'eye'. For another type of pattern, 'black mottled', NAGAI has found it recessive to full black but dominant to full brown. Concerning these patterns, the following genes have been established by him :

- H** : a gene fully inhibiting the formation of the chromogenic substance ; **h** : no effect.
- K** : a gene partially inhibiting the formation of the pigment, so resulting in the 'eye' pattern ; **k** : no effect.
- M** : a gene for the 'mottled' pattern ; **m** : no effect.

Cotyledon Color. TERAÔ (590), from his experimental results, concludes that the inheritance of the cotyledon color (green or yellow) is absolutely maternal.

WOODWORTH (859), however, states that there was no evidence of maternal inheritance as shown by TERAÔ. Cotyledon color in F_2 of certain crosses showed aberrant ratios which were interpreted as 15 : 1. According to the opinion of WOODWORTH, four genes are involved for cotyledon colors—**Y** : a gene for yellow pigment ; **G** : a gene for green pigment ; **I** : a gene causing the green pigment to disappear at maturity ; and **D** : a gene having the same effect as **I**. **Y** and **G** are present

homozygously in all varieties of Soy Beans, whether green or yellow seeded.

Thus :

$\left. \begin{array}{l} \text{YGid} \\ \text{YGiD} \\ \text{YGid} \end{array} \right\} \dots \dots \dots \text{yellow}$
 $\text{YGid} \dots \dots \dots \text{green}$

Other Characters. Several works concerning the inheritance of some morphological characters are here briefly summarized in TABLE VIII.

TABLE VIII.—INHERITANCE OF SOME CHARACTERS IN *Glycine Soja*.

Contrasted characters	F ₁	F ₂	Authors
<i>Flower Color</i> Purple—white	Purple	3 purple: 1 white	{ PIPER & MORSE (139) WOODWORTH (1100) TAKAHASHI & FUKUYAMA (1333)
Almost complete correlation exists between flower color and stem color; purple flowers are accompanied by dark stems, and white flowers by green stems.			
TAKAHASHI & FUKUYAMA also recognized in F ₂ a digenic ratio of 9 purple : 3 purplish red : 4 white.			
<i>Pod Color</i> Dark brown—light brown	Dark brown	3 dark: 1 light	{ WOODWORTH (1100) TAKAHASHI & FUKUYAMA (1333)
<i>Hair Color</i> Tawny—gray	Tawny	3 tawny: 1 gray	{ PIPER & MORSE (139) WOODWORTH (859)
<i>Leaf Form</i> Broad--narrow	Intermediate	1 broad: 2 intermediate: 1 narrow	{ TAKAHASHI & FUKUYAMA (1333)
<i>Number of Leaflets</i> Five—three	Five	3 five : 1 three	
In the five-leaved parent, the number of leaves with five or four leaflets in the main stem was 73%, while in the F ₁ plants the percentage was somewhat lower (52%).			
<i>Plant Surface</i> Glabrous—pubescent	Glabrous	3 glabrous : 1 pubescent	NAGAI & SAITÔ (1060)
<i>Growth Habit</i> Tall, luxuriant, late maturing—low, compact, early maturing	Tall	3 tall : 1 low	WOODWORTH (1100)

Linkage Relations¹⁾. 1) According to WOODWORTH (859), there is

1) The haploid chromosome number in *Glycine Soja* is 20. (Vide TISCHLER, *loc. cit.*)

an apparent repulsion between green seed coat and yellow cotyledon, and conversely between yellow seed coat and green cotyledon. Evidence indicates about 13% crossing-over.

2) WOODWORTH also reports that the gene for tawny pubescence and the gene for black hilum color are completely linked.

3) According to NAGAI & SAITÔ (1960), a linkage relation exists between the gene for glabrousness (**P**) and the gene for the mottled pattern in the seed coat (**M**). Percentage of crossing-over is about 18.12.

Godetia amoena

RASMUSON (1953, 1951) has published works on this plant.

Spotting on the Petals. With respect to spotting on the petals, two varieties were found, one with a red spot at the base of the petals ('Basalfleck') and the other with a more lilac red spot across the middle part of the petals ('Querfleck'). The F_1 plants between these two types possessed both spots, and gave in F_2 'Querfleck', double spot and 'Basalfleck' in a 1:2:1 ratio. Both types of spots, when crossed with unspotted varieties of *G. Whitneyi*, gave in F_2 a 3 (spotted): 1 (unspotted) ratio. RASMUSON suggested either multiple allelomorphism or close linkage between two genes (**K** and **L**), preferring for the present the latter assumption.

Doubleness of Flowers. There are two double-flowering varieties in *G. amoena*. One has only a few double flowers with seldom more than 5-6 petals, the other has all or nearly all flowers double and mostly with a large number of petals. Doubleness was found to be dominant to singleness, depending on a single gene, **U**. The gene **U**, however, is much influenced by the spotting genes **L** and **K**. Basal-spotted flowers (**LLkk**) are more double than double-spotted ones (**LlKk**) and these more double than 'Querfleck' (**llKK**).

Godetia Whitneyi

RASMUSON (1953, 1951) has also studied the inheritance of several characters in *G. Whitneyi* and also in the species cross with *G. amoena*. The characters investigated were color, size and doubleness of corolla, color and shape of leaves, and habit of growth.

Flower Color. A number of crosses showed that pure white is dominant to yellow-margined white, colored to white, red to lilac,

rose-lilac to lilac, red-spotted to lilac, red to red-spotted, large spot to small spot, and light-margined red to pure red. The F_2 segregation led him to assume the following several genes for flower color:

- A**: a gene for non-yellow flowers, its absence producing yellow-margined petals.
- B**: a gene giving pale lilac in the absence of other dominant color genes.
- C**: a gene producing rose color, the heterozygotes being often nearly white.
- D**: together with **B** or **C**, gives lilac, it alone having no effect.
- E**: a gene producing red.
- F**: together with **E**, gives red petals with paler margin, **F** alone having no visible effect.
- G**: produces a red spot in the middle of the petal, the heterozygotes having a smaller spot.
- H**: enlarges the spot produced by **G**, but by itself has no effect.
- I**: gives rose-lilac color probably in presence of **B**.

Size of Flower. As to the size of the corolla, it was found that plants with yellow-margined petals (**aa** plants) have distinctly smaller corollas, though it is probable that other genes are also concerned in corolla length.

Doubleness of Flowers. Single flowers are more or less completely dominant to double ones.

Growth Habit. The difference between the low, dense growth habit and the high, lax type was shown to be monogenic (Gene = **R**), the latter type being dominant.

Leaf Color. Dark green leaves are incompletely dominant to light green ones. The F_2 segregation suggested that at least two pairs of genes are involved.

Leaf Form. As to the shape of leaves, segregation was shown in F_2 from several crosses. The genes for length and breadth were found to behave more or less independently. Probably only a few pairs of genes are involved.

*Linkage Relations.*¹⁾ It was stated that linkage exists between some color genes, **B** and **E**, **E** and **G**, **C** and **F**. (See under '*Flower Color*'). Three allelogenes, **Bb**, **Ee** and **Gg** are thus in the same chromosome pair. The crossover percentage for the **B** and **E** pair was calculated as 14.3. **C** and **F** are thought to be in the 2nd chromosome pair. The gametic ratio for them has not yet been determined.

1) The haploid chromosome number in *Godetia Whitneyi* is 7. (Vide TISCHLER, loc. cit.)

Species-Crosses. The species-cross between *G. Whitneyi* and *G. amoena* gave F_1 plants which were almost completely sterile, and only a few plants were raised in F_2 . A segregation in F_2 , however, was observed as to flower color, doubleness of flowers, height of the plant, length of the internodes in the rachis, and incompletely as to color and shape of the leaf. Among these, the genes concerned in flower-color, doubleness of flowers and height of plants proved to behave in exactly the same manner as in the varietal crosses.

Gossypium

COLOR INHERITANCE

Flower. Results obtained by different authors, regarding the inheritance of petal color in cotton hybrids, have varied considerably.

FLETCHER (73), crossing a red-flowered with a yellow-flowered Indian cotton (*G. herbaceum*), obtained in F_1 approximately equal numbers of reds and yellows. F_2 progenies of red F_1 plants comprised 428 red-flowered and 114 yellow-flowered individuals (ratio 3.75 to 1), while F_2 populations grown from yellow F_1 plants comprised 474 yellow-flowered and only 12 red-flowered individuals. He made also crosses between yellow flower and white flower, and found the former to be a dominant character. This fact was later verified by FYSON (93), who used similar Indian varieties.

BALLS (86, 152) found that in a hybrid of upland (*G. hirsutum*) with Egyptian cotton (*G. barbadense*), petal color was intermediate or 'lemon' in F_1 , while F_2 showed segregation into yellow, intermediate and white in a ratio of 1 : 2 : 1. In a later publication (214), however, he suggests that "petal color in crosses of upland by Egyptian may be controlled by not less than *three* pairs of allelomorphs."

LEAKE (182, 183) and LEAKE & PRASAD (355), working with Indian cotton, found that yellow is monogenically dominant to white. They distinguished two kinds of yellow colors, a full yellow and pale yellow, and recognized the difference to be monogenic, the former being dominant. From a cross between red or yellow and pure white, LEAKE obtained red on yellow in F_1 , and in F_2 four types: red or red on yellow, red on white, yellow and white in a ratio of 9 : 3 : 3 : 1. Red-flowered plants had always red foliage. For interpretation of these results the following two genes were assumed :

Y : a gene for yellow, its absence resulting in white.

R : a gene for red ; individuals heterozygous for **R** have petals only partially colored.

The scheme of the genes may be represented as :

	<i>Flower</i>	<i>Foliage</i>
Y(Y)RR	red	vein & lamina red,
Y(Y)Rr	red on yellow . .	vein red,
yyR(R)	red on white . .	„ „
Y(Y)rr	yellow	green,
yyrr	white	„

On the other hand, McLENDON (1330) reports that in hybrids of sea-island cotton (*G. barbadense*) with upland varieties, F_1 was intermediate in petal color, while in F_2 the full yellow color of the sea-island parent was not recovered, and a much greater number of individuals had petals of intermediate color (pale yellow) than those with white petals.

Later HARLAND (701), studying crosses of some of the 'nature' cottons with upland and with sea-island, distinguished six grades of color from white (grade 0) to very deep yellow (grade 5), all breeding true. Ten different combinations were made among these, and it was found that "a cross between any two of the above shades gave an intermediate F_1 , and in F_2 the parental and F_1 colored types appeared, but there may have been other intermediate color forms in addition." The most extreme cross, (0 $\times$ 5), gave in F_2 a ratio of 1 (very deep yellow) : 7.2 (intermediate) : 4 (white). The combination of 0 $\times$ 3 gave in F_2 4.4 (yellow) : 1 (white).

Still later KOTTUR (1045) made a cross between a full yellow-flowered Indian cotton (*G. herbaceum*) and a pure white-flowered type (*G. neglectum* var. *rosea*), and found that the F_1 plants were pale yellow-flowered, giving in F_2 the ratio 3.9 (pale yellow) : 1.0 (full yellow) : 1.6 (white). All white-flowered plants were pure recessives, and the full yellow plants, homo- or heterozygous, were dominant ; for some of these bred true, while others gave progeny with both pale yellow and full yellow flowers or with flowers of all these colors. Plants with pale yellow flowers have never bred true in this color character, and progeny has been a mixture of pale yellow and white, of pale yellow and full yellow, or of all these colors in widely different proportions, so they were considered to be heterozygotes.

Recently KEARNEY (1037, 1171), in crosses between upland (Holdon) and Egyptian (Pima), obtained an intermediate and uniform F_1 and a

unimodal frequency curve in F_2 , extending from one to the other parental extreme. The F_2 mode was intermediate, but the number of individuals which had the petals lighter colored than the intermediate shade greatly exceeded the number having deeper yellow petals.

As to the inheritance of the spot on the petal, BALLS (86, 214) in a cross between 'full red-spot' Egyptian and 'spotless' upland obtained an intermediate F_1 . In F_2 a ratio close to 3 (full-spotted): 9 (intermediate): 4 (spotless) was found, suggesting two independent genes. Other series of crosses, however, gave an entirely different ratio. In one of these, F_2 progenies comprised 27 full-spotted, 41 intermediate and 112 spotless individuals. The ratio was explained on the assumption that the petal spot was controlled by two genes, with 3:1:1:3 gametic coupling.

However, according to other investigators—LEAKE (182, 183), LEAKE & PRASAD (355), McLENDON (1330), and KEARNEY (1170)—the difference between spotted and spotless is in general monogenic, the dominance being incomplete in F_1 , and giving a 3:1 ratio for spotted as contrasted with its complete absence in F_2 .

Red Spot on the Leaf. The character is due to the anthocyanin development in the epidermal and subepidermal tissues of the petiole at the point where it passes into the leaf-veins. In upland and in Hindi this spot is conspicuous, in Egyptians it is fainter and smaller. According to BALLS (86), crosses of spotted with relatively spotless gave spotted F_1 , but the intensity of the color is lighter than in the spotted parent. Classifying the F_2 population as 'spotted', 'intermediate' and 'no spot', he obtained a close approximation to a 1:2:1 ratio. Extracted full-spotted and spotless bred true.

Later KEARNEY (1037) showed that in the Holdon-Pima hybrid the F_1 and F_2 means were approximately intermediate although nearer to that of the Holdon parent, and there was no indication of a plurimodal frequency distribution in F_2 .

Cotyledonary Stalk. KOTTUR (1045) crossed the deep red-stalked type (*G. neglectum*) with the green-stalked type (*G. herbaceum*). The F_1 plants were faint red colored, giving in F_2 a ratio of 1 (deep red): 7 (faint red): 1.5 (green). He states that "it is quite unsafe to suggest any reason for this proportion, on the basis of the two generations considered."

Anther. Hybrids of Egyptian (yellow) and upland (white) varieties made by BALLS (86, 214) showed the F_1 anther color to be intermediate and a 1:2:1 ratio was obtained in F_2 .

McLENDON (1330), in his sea-island-upland hybrids, obtained results for anther color similar to those which he obtained in regard to petal color, and in fact his data indicated that the same gene governs the yellow color of the petals and the anthers. On the other hand, complete independence of the genes for yellow color in the two organs was indicated in the Holdon-Pima hybrid. In a similar cross, KEARNEY (1037) secured partial dominance of the yellow color in F_1 and some evidence of bimodal distribution in F_2 .

Lint. In one of crosses between a brown (or green) Egyptian and a white (or paler green) upland, BALLS (86, 214) obtained an intermediate (cream) F_1 and in F_2 brown, cream and white in a 1 : 2 : 1 ratio. Another cross (Charara $\times$ King) gave also intermediate F_1 , while in F_2 9 brownish, 60 cream and 109 white were obtained. Still another cross of a dark brown haired upland with a white of the same group gave F_1 plants with intermediate color, and in F_2 segregation occurred normally.

Fuzz. BALLS (86, 214) found the green color incompletely dominant to white and brown.

According to COOK (90), hybrids between the Kekchi cotton and the sea-island showed a dense coat of bluish green fuzz, while neither parent showed any such green fuzz. The green color, however, tended to disappear in the later generations, a fact contradictory to the Mendelian expectation.

FLOWER CHARACTERS

Length of the Petal. BALLS (214) records that the difference between long and short petals was monogenic, the long petal being dominant. All the extracted shorts bred true up to F_6 . LEAKE (182, 183) noted the close linkage between the length of petal and the color, small petals being always white, and yellow petals invariably long.

KOTTUR (1045) grouped in his experiments all petals measuring more than 22 mm. in length under large petals and all petals below this limit under small petals. The F_1 of the cross, large (*G. herbaceum*) $\times$ small (*G. neglectum* var. *rosea*), indicated a tendency of dominance of the large petal. The segregation of the types in F_2 was, however, very curious, for F_2 progenies comprised only 228 plants with large petals and 643 with short petals, or a ratio of 1 to 2.8, being nearly the reverse of what had been expected. It was also found that the correlation of white flowers with short petals was not so complete as in the

cases examined by LEAKE, for out of 252 white flowered plants, 243 gave flowers with short petals and 9 with large petals.

Number of Loculi of the Ovary. A detailed study with respect to this character was made by BALLS (153, 214). The ovary of the cotton flower consists of several loculi, from 1 to 7. One of crosses investigated was made between an upland with its mean number at 4.3 and an Egyptian with a mean at 3.0. It produced an intermediate F_1 with a mean at 4.1. In F_2 a wide range of 3.0 to 4.7 was obtained. Extreme types proved to be homozygous, while intermediate types segregated again. Apparently more than one pair of allelomorphic genes are concerned in this character. Later HARLAND (1017) confirmed this multigenic conclusion from his experiments with several varieties of cotton (sea-island, upland, etc.).

SEED CHARACTERS

Weight of the Seed. Regarding the inheritance of weight and size of seed, BALLS (86, 153, 214) obtained the following results. An inter-Egyptian cross (Sultani $\times$ Afifi) between parents of almost identical seed-weight gave the F_1 seeds rather heavy, and in F_2 wide variations between the parental extremes, with indications of three modes. Another cross between Egyptian and American upland (Afifi $\times$ Truitt) gave very heavy F_1 seeds, while in F_2 a simple segregation of one light seed with three heavy seeds was obtained. In still another cross between Egyptian and upland (King $\times$ Charara) in which the parents showed almost equal seed-weight, the F_1 seed leapt up in weight to nearly double that of either parent, and the F_2 showed a unimodal curve ranging between the two extremes of parents and F_1 .

Length of the Lint. BALLS (66, 86, 153, 214) with Egyptian and COOK (109) with American cottons showed that long lint behaved as a character completely dominant to short. Similar results were also reported by FLETCHER (73), FYSON (93) and THADANI (1221). LEAKE (184) with Indian forms obtained, however, another result in which F_1 plants were intermediate. BALLS gave in F_2 from an inter-Egyptian cross (Afifi $\times$ Sultani) a continuous segregation of length between two parental forms, indicating the presence of several genes. KEARNEY (1037) reported a similar case in his Holdon (short)-Pima (long) hybrid.

KOTTUR (1045) classified staples above 21mm. as long and those below and including 21 mm. as short. The cross, *G. herbaceum* (long) $\times$ *G. neglectum* var. *rosea* (short) showed almost complete dominance of long

staple. In F_2 , however, he obtained out of 500 total plants, 282 plants of long staple and 218 of short staple, or a ratio of 1.6 to 1. Taking the color of lint into consideration, however, the segregation was as follows:

117 brown-short: 3 brown-long: 279 non-brown¹⁾-long: 101 non-brown-short.

Thus the correlation between brown color and short staple was so complete, and this fact was considered to interfere with the normal operation of the Mendelian law. When the brown colored cottons are put out of consideration, the staple length seems to behave as a simple Mendelian character, the ratio of long to short being 2.7 to 1.

Distribution and Amount of the Lint. According to BALLS (66, 86, 214), a regular distribution of lint on the seed is dominant to an irregular distribution, and segregation seems to occur in F_2 . But the exact mode of inheritance has not been determined.

As regards the amount of lint, KOTTUR (1045) made a detailed experiment. The ginning percentage of the seeds of one parent (*G. neglectum*) was 35.1 in the mean, and that of the other (*G. herbaceum*) 28. The resulting F_1 plants showed 34.2 ginning percentage, indicating that the high ginning percentage is nearly completely dominant. In F_2 a wide range of variation from 23 to 43 per cent was obtained, but grouping the plants with a percentage of 29 or below as having a low ginning percentage and those above this point as having a high percentage, the proportion of F_2 was almost exactly 3 high to 1 low. The results obtained from later generations confirmed the fact that the difference is monogenic. It was also found that the ginning and the staple characters behave as genetically independent characters, the F_2 distribution (excluding the plants producing brown tinted cotton) approaching the normal dihybrid ratio: 9 (high ginning and long staple): 3 (high ginning and short staple): 3 (low ginning and long staple): 1 (low ginning and short staple).

According to THADANI (1091, 1221), crosses between a strain of upland cotton having little or no fiber on the seed (its ginning percentage being 0—10) with upland varieties having abundant fiber (ginning percentages being 26—36) gave results indicating that the 'lintless' condition is governed by a single recessive gene.

Presence and Absence of the Fuzz. FLETCHER (73) records dominance of the fuzz in a cross of a fuzzy-seeded with a naked-seeded cotton, while

1) White or dull white.

FYSON (93) from his experiments reported dominance of the smooth-seeded condition, but no definite segregation was observed in F_2 , there occurring several intermediate grades of fuzziness. BALLS (86, 105, 214) crossing an entirely fuzzy-seeded upland with an Egyptian having only a little fuzz on the seeds obtained in F_1 plants entirely fuzzy-seeded like the upland parent. The F_2 population consisted of 147 plants with entirely fuzzy-seeded and 8 plants resembling the Egyptian parent. The ratio was considered to point to a digenic ratio of 15:1. In crosses between two Egyptian varieties differing in the amount of fuzz, he found the difference monogenic, more fuzz being dominant to less fuzz. In another cross, Egyptian (Charara) $\times$ Hindi, the seed of the latter being devoid of fuzz, a complex mode of inheritance was observed. The F_1 seeds were entirely fuzzy, like an upland. In F_2 the ratio of two types, entire : Egyptian, was found to be 14:3 in one case, 123:7 in another, without producing a single Hindi seed. Still another cross between a naked Hindi and an unnamed plant which bore slightly fuzzy seeds like the Egyptian gave in F_2 the monogenic ratio of 3 slightly fuzzy : 1 naked.

McLENDON (1330), in hybrids of the smooth-seeded sea-island cotton with fuzzy-seeded upland varieties, found dominance of fuzziness in F_1 , but little evidence of any definite segregation.

KEARNEY (1037) reports almost complete dominance of the entire fuzziness of the upland parent over the partial fuzziness of the Egyptian. The F_2 segregation suggested that several genes are involved in this character. Similar results were obtained by THADANI (1091, 1221) in his crosses between partially-fuzzy and entirely-fuzzy seed. He also made crosses of a naked seeded Hindi variety with fuzzy-seeded uplands, and found a monogenic difference, with complete dominance of nakedness. Another cross of the Yuma variety of Egyptian cotton having most of the seed coat naked with a completely fuzzy-seeded upland variety showed that the nearly naked condition was dominant in F_1 , and an irregular segregation into 5 classes occurred in F_2 . With respect to density of fuzz, he found three grades among the seed classed as entirely-fuzzy, namely, woolly felted and scanty-fuzzy. The last two types proved to be dominant to woolly seed in F_1 .

OTHER MORPHOLOGICAL CHARACTERS

Height of Stem. BALLS (86) found that tallness of the main stem behaved as a complete dominant over shortness. In F_2 a wide range of

variation was obtained. Similar results were also reported by McLENDON (1930).

Growth Habit. According to LEAKE (182, 183), when a monopodial and a sympodial type are crossed, the heterozygote, though intermediate, approximates to the sympodial type. In F_2 a series of forms is obtained, some of which in the vegetative period are as short as, or shorter than, that of the sympodial parent, while a few reach the length of the full monopodial parent.

As regards the inheritance of fasciation, LLOYD (562) obtained results indicating that the character is dominant to the normal condition.

Leaf Shape. Results obtained by BALLS (86, 214) with respect to the inheritance of leaf shape were as follows:

1) King upland with a mean leaf-length of 75 mm., crossed with Charara, the mean leaf-length of which was about 135 mm., gave an F_1 with leaves rather shorter than Charara. F_2 ranged from 70 to 195 mm., most of plants lying between the parental extremes.

2) The distance from petiole-apex to sinus was shown to be inherited independently of the length of the midrib. The mode of its inheritance is similar to that of the leaf-length.

3) On crossing the narrow angle of upland with the wide angle of Egyptian, a wide angle was obtained in F_1 . In F_2 a wide range of variation appeared, with some indication of simple segregation of narrow angle from wide.

FYSON (93) crossed two distinct species grown in India, one having broadly and shallowly lobed leaves (*G. herbaceum*), and the other deeply and narrowly lobed leaves (*G. neglectum*), and obtained only the latter type in F_1 . The record of F_2 was not given, but of 13 F_3 progenies 5 showed only the deeply and narrowly lobed type, 4 progenies showed practically only the broadly and shallowly lobed type, and 4 progenies gave a 3 to 1 ratio, the deeply and narrowly lobed type being dominant. Similar behavior continued in F_4 and F_5 , some of the dominant type breeding true and others showing segregation in approximately a monohybrid ratio, while the recessive type (broadly and shallowly lobed) bred true with a few exceptions, which he attributes to accidental cross-pollinations.

LEAKE (94) determined by measurement a leaf index $\frac{\text{length}}{\text{breadth}}$ of the lobes of a leaf, and found that the hybrids between *G. herbaceum* and *G. arboreum* or *G. neglectum* are exactly intermediate approximating remarkably to the arithmetic mean of those of the two parents. In later papers (182, 183), similar results in F_1 and a close approximation to a 1:2:1 ratio in F_2 were recorded.

SHOEMAKER (120) crossed two upland cottons, one being an 'Okra leaf' (deeply and narrowly lobed) type segregated from the King variety, and the other being the Edson variety with relatively shallow and broad-lobed leaves, and confirmed results of LEAKE, F_2 segregation being in a 1 : 2 : 1 ratio. Similar results were also obtained by McLENDON (1330).

KOTTUR (1045), working with crosses between *G. herbaceum* and *G. neglectum* var. *rosea*, obtained the F_1 plants with long and broad-lobed leaves, the range of length extending, however, beyond the longest leaf of the *rosea* parent. In F_2 the typical dihybrid segregation occurred, viz. 9 (long, broad) : 3 (long, narrow) : 3 (short, broad) : 1 (short, narrow).

On the other hand, KEARNEY (1037), studying Pima and Hold-on hybrids, showed that the mean leaf index of F_1 was higher than that of either parental population, the leaves having been much wider than in Pima. The mean leaf lobe index of F_1 was almost exactly the same as that of Pima, the more deeply lobed parent. In F_2 the frequency distributions for both indices resemble normal curves, indicating that several genes are involved in each of these characters.

Form of the Stipule. BALLS (214) crossed Sultani with Afifi, the former having long narrow stipules, while the stipules of the latter are about four times as wide for the same length. The F_1 stipule was long and narrow like that of the Sultani parent. In F_2 48 plants had stipules like the Afifi, 59 like the Sultani, while 27 were recorded as doubtful.

Presence and Absence of Nectaries. According to KOTTUR (1045), the presence of both foliar and extra floral nectaries is characteristic of *G. herbaceum*, while in the case of *G. neglectum* these organs are sometimes present, but sometimes completely wanting. It was found that the presence of nectaries behaved as a dominant character in F_1 , but in F_2 a ratio different from the normal Mendelian one was obtained.

Hairiness of Petiole. BALLS (86) reports that the glabrous condition of the Egyptian parent was dominant to the hirsute condition of the upland cotton. An F_2 progeny showed an exact 3 (glabrous) to 1 (hirsute) ratio. In a later paper (214), BALLS states, however, that complete dominance of the glabrous condition does not occur in F_1 , and that the segregation in F_2 and later generations is such as to indicate that several genes are concerned. Certain F_5 progenies were stated to have "bred true to new types of hirsuteness."

According to McLENDON (1330), the hairiness of the upland cotton was incompletely dominant to the glabrousness of the sea-island parent. In F_2 a wide range of variation extending from one extreme to the other was obtained.

Recently KEARNEY (1037), dealing with the Holdon-Pima hybrid, concluded that the F_1 mean for petiole hairiness indicated a slight tendency to dominance of the practically glabrous condition of the Pima parent. In F_2 approximately $2/3$ of the population was as glabrous or nearly as glabrous as Pima, while a few individuals were much hairier than the Holdon parent.

Chlorophyll Characters. BALLS (86) made crosses between an upland cotton with light green leaves and a dark green Egyptian cotton. In F_2 plants with light green leaves and those with dark green leaves appeared in a 3:1 ratio.

STROMAN & MAHONEY (1307) studied with two seedling types of chlorophyll deficiencies: yellow seedlings and pattern seedlings. Yellow seedlings contain only a small amount of chlorophyll, and die as soon as the stored food of the seed has been used up. These plants were found in F_2 from Egyptian-upland crosses. It was found that yellow seedlings are determined by the double recessive condition of two genes, Y_1 and Y_2 . Pattern seedlings are characterized by certain areas devoid of green color on the young cotyledons, surrounded by normal green pigment. The deficient areas are of a rich yellow in some strains, and white in others. The chlorophyll of pattern seedlings sometimes reduces to a small amount throughout the leaf.

Boll Character. 1) Boll-lock number. BALLS (214) explained results obtained concerning this character in hybrids between upland and Egyptian and between different varieties of Egyptian cotton on the multiple gene basis. A similar interpretation was adopted by KEARNEY (1037, 1171) who obtained in F_2 of the Holdon-Pima hybrid an unimodal and fairly symmetrical frequency distribution regarding this character.

2) Boll shape. BALLS (214) expressed the form by the index width/length. A cross between an upland with a mean form of 0.75 and a width of 31 mm. and an Egyptian with a form of 0.58 and a width of 27 mm., gave an F_1 with a form of 0.60 and a width of 32 mm. The F_2 ranged up to the F_1 width and form, but new forms of the extremely narrow bolls were also obtained. The character was assumed to involve several genes. The result obtained by KEARNEY (1037) pointed also to the presence of multiple genes. McLENDON (1330), working at sea-island-upland hybrids and classifying by inspection, concluded that the short thick type of boll is purely recessive, although the long, slender type was not completely dominant. In F_2 he obtained a monogenic ratio of 1 (short and thick) : 3 (remaining forms).

3) Boll surface. The surface character, smooth or pitted, is due to the depth at which the resin glands are situated in the ovary wall. In most Egyptian bolls they are near the epidermis, which is depressed above them, forming small craters. In uplands the glands are situated much deeper below the epidermis, which is not depressed, so that the surface of the boll is smooth. BALLS (86), dealing with an upland-Egyptian hybrid, obtained an intermediate condition in F_1 and an approximately 1 : 2 : 1 segregation in F_2 into smooth, intermediate and pitted types. In a later paper (214), however, he states that the inheritance of this character is more complex than was supposed at first to be the case.

McLENDON (1330) reports also an intermediate F_1 condition in sea-island-upland crosses. The data from numerous F_2 populations, however, show ratios varying from 1 : 1 to 29 : 0 for pittedness vs. smoothness.

Later KEARNEY (1037), from his Holdon-Pima cross, concluded that "satisfactory grading with respect to boll surface, if it can be regarded as a single character, was not found to be practicable in the Holdon-Pima hybrid, although the parent varieties differed conspicuously."

PHYSIOLOGICAL CHARACTERS

Resistance to Rust. Regarding the inheritance of resistance to *Fusarium vasinfectum*, ORTON (192) made numerous crosses, and obtained very conflicting results. Every culture gave a different ratio between the number of healthy and diseased plants. In general the crosses behaved as if resistance was dominant, but many showed variability. This variability was probably due to heterozygosity of the parents with respect to wilt-resistance.

HARLAND (628) made some observations on the F_1 , F_2 and F_3 progeny of a cross between St. Vincent native cotton which is immune to the leaf-blister mite (*Eriophyes gossypii*) and Southern Cross upland, a susceptible type. The F_1 was intermediate, though inclining toward the susceptible parent; the F_2 progeny comprised 100 immune and 365 non-immune plants, indicating that the immunity behaves as a simple recessive. In F_3 immune plants bred true, and the non-immune again showed segregation.

Time of Maturity. FLETCHER (73) briefly records lateness as dominant to earliness. BALLS (86) made crosses between early uplands and late Egyptians. In F_2 a wide range of variation occurred beyond the combined range of the parents. By grouping the dates in early, intermediate and late, however, a 1 : 2 : 1 ratio was obtained.

Vegetative Period. LEAKE & PRASAD's experiments (355) showed that long and short gave an intermediate condition in F_1 , and a continuous series of variations in F_2 in which, however, plants with long vegetative periods were not obtained. Thus *G. arboreum* (200 days) $\times$ *G. neglectum* (60 days) gave the F_2 population which showed the vegetative period of 110 days as the modal value. They found also that this character shows a clear correlation with the mode of branching, its correlation coefficient being +0.6628 in one case, and +0.8589 in another.

LINKAGE RELATIONS¹⁾

THADANI (1091) dealt with the following several pairs of genes :

A :	naked-seeded,	a :	fuzzy-seeded.
B :	abundant-linted,	b :	sparse-linted.
C :	yellow-linted,	c :	white-linted.
D :	cluster,	d :	non-cluster.
G :	red-leaved,	g :	green-leaved.

A cross **Ab** $\times$ **aB** gave in F_2 segregation into **Ab**, **AB** and **aB** in a ratio of 1 : 2 : 1 (the actual data being 54 : 103 : 53), the double recessive **ab** type entirely lacking. In F_3 all **Ab** and **aB** plants bred true, and all **AB** segregated for both genes. The results were explained on the assumption of complete linkage of the genes **A** and **b**, and **a** and **B**.

A cross **Abc** $\times$ **aBC** gave results indicating close linkage, as before, of **A** with **b** and of **a** with **B**, while **Cc** segregated independently.

In another cross **Gd** $\times$ **gD**, the F_2 segregation indicated a linkage of **G** with **d**. The F_3 analysis was not yet carried out.

In still another cross, **AbgD** $\times$ **aBGd**, the F_2 was composed of only 9 phenotypes instead of the normal 16 types. The results, as before, indicated linkage of genes **Ab**, **aB** and **Gd**, **gD**. There was also an indication of linkage of the gene pairs **BG**, **bg** and **Ag**, **aG**.

Helianthus annuus

Flower Color. SHULL (101) made a cross between the wild species and the cultivated variety ('Russian Sunflower'). The former has the tips of the palea a deep metallic purple, while the latter has a yellowish

1) The haploid number of chromosomes is 13 in *Gossypium roseum*, *G. arboreum*, *G. neglectum* and *G. herbaceum*; 26 in *G. barbadense*, *G. hirsutum*, 'Afifi' and Egyptian races. (Vide TISCHLER, *loc. cit.*)

green disk. The results obtained indicated that the purple disk behaves as a dominant character against the yellow disk, and the segregation is normal.

According to COCKERELL (332, 333, 384), the normal orange form behaves as a simple dominant over the primrose-rayed variety which appeared as a mutant, while the coronatus character (red-rayed) is a simple dominant to the yellow type, though its expression is very variable. In a later publication (385), he showed that chestnut-red, wine-red, orange and primrose segregate in F_2 in a ratio of 9:3:3:1.

Other Characters. SHULL (101) found branching habit to be a simple dominant to unbranching.

SAZYPEROW (366) showed that the absence of pigment in the fruit is a pure recessive to its presence. Three genes were supposed to be concerned in fruit colors. He also in crossing a late-matured taller variety with an early-matured lower one found the latter type prevailing in F_1 over the former.

In another paper (312), the same author reported that the cross between a variety susceptible to the root-parasite, *Orobanche cumana*, and another resistant variety gave the F_1 plants showing a partial dominance of resistance, and in F_2 both susceptible and resistant forms were obtained.

Later (466) he made further the species-cross, *H. annuus* (♀) × *H. argonophyllus* (♂), the former being susceptible to the rust, *Puccinia Helianthi*, the latter resistant to the same. The F_2 results gave some evidence indicating that susceptibility is a monogenically dominant character. The same cross showed also certain segregation for several characters such as leaf-color, leaf-texture and branching habit.

Hemizonia congesta

BABCOCK & HALL (1107) have published a paper on this plant. The following description is based on their work.

Flower (Ligule) Color. In *Hemizonia*, there are several grades from darker to lighter tints of yellow in the ligules. This variation is due to difference in number of plastids in the cells. From the results of several crossings, it was stated that "at least one pair of genes conditions ligule color, and it seems probable that one or more other pairs of genes have a modifying effect on the degree of yellow color."

Anther-tube Color. A single plant was found which lacked the purple color in the anther-tubes of the disk-flowers. In this plant the

anther-tubes were cream-colored in the young flowers, turning to light brown with age. In crosses with purple, cream proved to be governed by a single gene, giving in F_2 a 3 (purple) : 1 (cream) ratio. Among cream F_2 plants, some were found to show a light tinge of purple confined to the ridge of the tube. Considering this character in addition, the F_2 distribution was 72 purple, 18 cream with purple ribs and 6 cream, which is exactly in a 12 : 3 : 1 ratio. In F_3 , however, an unexpected result inconsistent with this digenic basis was obtained: two F_2 cream plants (cream with purple ribs $\times$ pure cream) gave 2 F_3 progenies of purple, instead of cream, plants.

Abnormal Floral Structure. The ligulate corolla is normally 1-lipped, while some plants with 2-lipped ligules were observed. In this abnormal type, the added posterior lip stood erect, thus forming a crown surrounding the disk-flowers, as in the collarette type of Dahlia. The collarette ligule proved to be a simple recessive to the normal type of ray.

Habit of Growth. A plant was found which displayed the procumbent habit of growth. The character was not due merely to weakness of the supporting tissue in the shoots, but was a true negative condition of geotropic response in stem and branches. Some evidence indicated that the procumbent habit differs by a single recessive gene from the erect type.

BABCOCK & HALL made also some observations on the inheritance of height of plants, time of maturity, inter-sterility and other characters.

Hibiscus Sabdariffa

HOWARD & HOWARD (1154) worked with four varieties of *H. Sabdariffa*, and studied the color inheritance in them. The results obtained may be briefly summarized as follows:

1) Red color in the stem, leaves, corolla eye and pollen is dominant to its absence, and the segregation is normal. The gene was designated as **R**.

2) There is another gene which only affects the calyx and corolla, and causes the production of red color on the mature calyx and in the fading corolla. The gene was symbolized as **F**. The same gene produces also the red markings on the under side of the leaf and on the stem (both in axil of the leaves and below the petiole).

3) Continuous flushes of color present on the stem are controlled

by a single dominant gene **S**. This character is always associated with scarlet calyces and pink fading corolla, i.e., **S** is completely linked with **F**. There are further three genes concerning flushes, **M** for brown, **P₁** for pink and **N** for another brown. **P₁N** produces purple brown flushes, **MN** dark brown flushes and **SMN** purple flushes slightly darker than those caused by **SM**.

4) As to color of the sepal tips, the following scheme of genes was given :

GISr yellow,
GiSr olive green,
GIsr green,
Gisr bright green.

It was also found that the dark red color in the mature calyces is dominant to the pink.

Hordeum

COLOR INHERITANCE

Glume. TSCHERMAK (11) obtained results indicating a monogenic difference between the black and the colorless glumes, the black color being dominant. The same results were obtained by BIFFEN (59, 70), HAYES, STAKMAN, GRIFFEE & CHRISTENSEN (1020), GRIFFEE (1257) and other investigators.

For purple color, TSCHERMAK (1006) made a cross of black with purple, and obtained in F_2 black, purple and white in a ratio of 12: 3: 1, indicating that two independent genes are involved in these characters. The scheme of genes was represented as: **AB** and **Ab**=black, **aB**=purple, **ab**=colorless.

A cross between dark purple and colorless was made by MIYAKE & IMAI (939). F_1 was purple, and in F_2 dark purple, light purple and colorless were obtained in a ratio of 9: 6: 1. The results were explained on a 2-gene basis, namely: **P₁P₂**=dark purple, **P₁p₂** or **p₁P₂**=light purple, **p₁p₂**=colorless.

Grain. According to TSCHERMAK (1006), BIFFEN (59) and UBISCH (663), the dark color (black or purple) behaves as a dominant over the light color (yellow or white), giving in F_2 a monohybrid segregation.

TSCHERMAK states that the cross of black with yellow gave in F_2 black, pure purple, purple tinged with green, yellowish green and yellow; purple $\times$ yellow gave pure purple, purple tinged with green,

yellowish green and yellow. On crossing black (**Ab**) with purple (**aB**), he obtained in F_2 white grains due to a new combination of the genes.

MIYAKE & IMAI (939) obtained results indicating a single gene difference between blue and yellow.

KAJANUS & BERG (1165) made a cross of yellow with dark violet-brown. The mode of inheritance was complex but an explanation was suggested on a 2-gene basis: gene **A** controlling the blue color of the aleurone and gene **B** controlling brown in the pericarp. Without **A** the aleurone is colorless; without **B** the pericarp is yellow. The presence of both **A** and **B** produces the violet-brown of the grain.

EAR CHARACTERS

Awns and Hoods. The hoods ('Kapuze') of barley is a special form of awns having the shape of short, thick projections. TSCHERMAK (11, 1006) showed that in crosses of hooded varieties with awnless varieties the awnless condition was dominant, giving a monogenic segregation in F_2 . The same author obtained further results indicating also a single gene difference between hooded and awned forms, the hooded condition being dominant. Similar results have been obtained by THATCHER (266), KEZER & BOYACK (557), BLARINGHEM (759, 874) and other investigators. For the interpretation of these results, TSCHERMAK assumed three genes: **A** inhibits the production of awns and hoods, **B** stands for the hood and **C** for the awn. Hence the awnless form has the genic constitution **AbC**, the hooded form **aBC**, and the awned form **abC**.

Different results were obtained by MIYAKE & IMAI (939). A cross between awnless varieties and long awned 6-rowed barleys gave in F_2 the ratio of awned to awnless approaching 63:1. In other crosses of awnless varieties with awned 2-rowed varieties, they obtained the awned and the awnless plants in a 255:1 ratio (the actual number obtained being 1157:6), indicating that four genes (**A**₁, **A**₂, **A**₃, **A**₄) were involved in the awn production. The same authors showed further that in F_2 of a cross of awnless × hooded a dihybrid ratio of 9 hooded to 7 awnless was obtained, indicating that the hooded condition depended upon the presence of two genes **C**₁ and **C**₂.

On the other hand, UBISCH (663, 1095) found that crosses of awnless barleys with awnless gave only awnless; awnless with short-awned gave in some cases awnless and in the other reduced hooded; awnless with hooded gave only hooded. These results were explained by assuming

three genes, **A**, **K** and **S**, independently inherited. Either **A** or **K** alone originates awned forms; when both the genes are present, the hooded condition is produced. **S** is an inhibitor for the awn development and is epistatic to either **A** or **K**, but not completely dominant to the combined effects of **A** and **K**, resulting in a much reduced hooded form. Hence the varieties may be represented as:

AKS		reduced hooded,
AKs		common hooded,
AkS	}	 awnless,
aKS		
Aks	}	 awned.
aKs		
aks		

PARK (1063) observed striking variability in F_2 of a cross Arlington awnless $\times$ Olds White Hull-less (hooded). The plants ranged in an almost continuous series from long awns like those of typical awned varieties to completely awnless, and from mere traces of hoods to very large hoods. The results were explained on a digenic basis, **H** for hoodedness, its absence resulting in awned conditions, and **S** for partial suppression of the effect of **H** or **h**. It was also assumed that double **Ss** act more strongly than a single **S**.

ENGLEDOW (1134) made a careful study of the effects of late and early sowing on awn-development. It was found that grains from a pure line of *H. inerme* which was known as a completely awnless variety, when sown after February, would give plants with awns of varying length. In crosses of the *inerme* with *H. decipiens* (fully awned), the F_1 plants had awns of intermediate length. In F_2 , however, this F_1 type did not reappear, and fully awned and completely awnless were obtained in approximately a 3:1 ratio, indicating that the parents were different monogenically. The gene depends entirely on the time of sowing for its proper expression.

Awn Length. With respect to awn length, UBISCH (663, 1095) treated the forms with awn length of 6 cm. or longer as long-awned and with lengths shorter than 6 cm. as short-awned. With this grouping, she recognized one main gene-difference (**Aa**) for long versus short, together with one or two modifying genes with less effect. The gene **A** is active only in the absence of **K** (see under '*Awns and Hoods*'). A similar monohybrid segregation has been obtained by MIYAKE & IMAI (939).

As regards awn length of the lateral florets¹⁾, MIYAKE & IMAI (939) obtained the following results:

- 1) Awnless $\times$ awned $\rightarrow F_1$, intermediate $\rightarrow F_2$, 1 : 2 : 1,
- 2) Awnless $\times$ short-awned $\rightarrow F_1$, awnless $\rightarrow F_2$, 3 : 1,
- 3) Awned $\times$ short-awned $\rightarrow F_1$, intermediate $\rightarrow F_2$, 1 : 2 : 1.

It was concluded from these results that these three forms constituted a series of triple allelomorphs.

IKENO (459, 1156) made a cross between the 6-rowed fully awned variety Kinukawa and the less typical 6-rowed awnless variety Nogenasi. The F_1 plants had the median florets long-awned, while the lateral florets were merely awn-pointed or at best very short-awned. The results in F_2 and still later generations were explained on the assumption of three genes. Gene **A** stands for the awned condition; gene **E** is of a similar nature, but has less effect than **A**; while gene **I**—in the homozygous condition—inhibits awn formation on the lateral florets. It was supposed further that **II** partially suppresses also the median awn. Thus the scheme of the genes is as follows:

AEI		long-awned (lateral florets awnless),
AEi		full-awned,
AeI		middle-awned (lateral florets awnless),
aEI		short-awned (" " "),
Aei	}	middle-awned,
aEi		
aeI		awnless (lateral florets awnless),
aei		short-awned.

Structure of Awns. HARLAN (697) found a single gene difference between rough and smooth forms, and the dominance of the former type. According to a careful morphological study by VAVILOV (851), there are various types of teeth and also various degrees of smoothness, but no varieties which lack the teeth on the entire length of the awn. Crossing experiments by VAVILOV showed that rough $\times$ rough produced in F_2 some smooth-awned types. Several genes, at least five or six (**Z**₁, **Z**₂, **Z**₃, etc.), have been assumed for the teeth formation.

HAYES *et al* (1020), in a cross of Lion (smooth) $\times$ Manchuria (rough), showed the F_2 ratio of rough to smooth-awned plants to be approximately 3 : 1. In this case the degree of smoothness of the smooth-awned segregates appeared to be influenced by other modifying genes

1) See also under '*Fertility of the Lateral Florets*'.

brought in by the smooth-awned parent. Homozygous lines with various degrees of smoothness were obtained in F_3 and F_4 .

A peculiar case has been reported by COLIN & TROUARD-RIOLLE (1995, 1242). They found that in the F_1 plants from a cross smooth-awned black barley $\times$ rough-awned Albert barley, some of the ears had smooth awns only, some had both smooth and rough awns, while in others, the awns were smooth for half their length and rough for the remainder. Later generations carried on to F_4 were too complicated to admit of any genic interpretation.

Recently GRIFFEE (1257), in his cross of Lion $\times$ Svanhals, reports that the distribution of F_2 plants indicates a 2-gene difference for roughness of the awn between the parents. Gene **R** was supposed to give rough awns, and gene **S** was held to produce intermediate-smooth awns in the absence of **R**. Thus we have:

RS	{		rough,
Rs	{		rough,
rS			intermediate-smooth,
rs			smooth.

The data obtained, however, suggested other genes which modify the degree of smoothness to a slight extent.

Form of the Glume. In most varieties of barley, the glumes are narrow; there are, however, some varieties in which they are oval-lanceolate. According to TSCHERMAK (11), and BIFFEN (59, 70), the narrow glume behaves as a simple dominant character against the broad glume.

SCHIEMANN (839) obtained some broad types in F_1 from crosses in which both the parents were narrow-glumed. Apparently two genes are involved in this character.

Some crosses, however, between two normal-glumed forms yield results different from the above, as was shown by HOR (1152). He obtained in F_2 narrow and broad forms in a ratio of 13 : 3. Two genes were assumed: **W** standing for broad, and **I** as an inhibitor of broad.

Teeth on the Glume. Some varieties of barley have teeth on the lateral nerves of the glume. TSCHERMAK (11) found a single gene difference between toothed and nontoothed varieties, the former type being dominant. UBISCH (476) described three kinds of teeth: teeth of type (a) are visible to the naked eye, type (b) are seen with the aid of a hand lens, while type (c) can be seen only with a microscope. Crosses between type (a) and a nontoothed form gave in F_1 an intermediate condition, and in F_2 , 3 (toothed and intermediate forms) to 1

(nontoothed) were obtained. She assumed three genes for this character; **G** for type (a), **G₁** for type (b), and **G₂** for type (c).

Hairs on the Rachilla, Glume and Elsewhere. The rachilla of the barley spike is covered either with long stiff and unbranched hairs or with short, fine and branched hairs. That these two types differ by a single gene, the long-hair character being dominant, has been found by several investigators, viz. BLARINGHEM (108, 760), VESTERGAARD (425), UBISCH (476), ENGLEADOW (690) and SCHIEMANN (1076). The same gene pair also determines the type of hair in the glumes, rachis segment, lodicule, and of basal bristle hair in a similar way.

It was found by HOR (1152) that the extent of pubescence on the glumes, however, is caused by another gene pair **Ss**. **S** is only partially dominant to **s** in the spreading effect, while **ss** restricts the hair to the central ridge.

Articulation of Rachis. Most varieties have a more or less articulate rachis. This articulation attains its maximum in *H. spontaneum* (the wild barley), the heads shattering quite easily. In crosses of *H. spontaneum* with other varieties with rather nonarticulate resistant rachis, SCHIEMANN (655) obtained a monogenic segregation in **F₂**, the articulate rachis being dominant. Articulate types were obtained by UBISCH (424, 663) from crosses in which both the parent varieties were nonarticulate (also BLARINGHEM, 108). In **F₂** plants with articulate rachis and plants with nonarticulate rachis appeared in an approximate 9 : 7 ratio. Apparently two genes must be present in either homozygous or heterozygous condition in order to produce articulation. These genes were designated by UBISCH as **B** and **R**. Two nonarticulate types **BBrr** and **bbRR** could be distinguished anatomically from each other.

Later SCHIEMANN (839) concluded from his experimental results that in addition to these, **B** and **R**, still other two genes, **X** and **C**, are involved in this character. The gene **X** inhibits, in the homozygous condition, the character 'articulation.' Thus the cross between two nonarticulate forms, **BrX** and **bRx**, gave in **F₂** articulate and nonarticulate plants in a ratio of 6 : 10, instead of 9 : 7. The second gene **C** was found in the cross of *H. spontaneum* with a 6-rowed naked barley. The **F₁** plants of this cross had articulate rachis, and the ratio of plants with articulate rachis to those with nonarticulate ones was approximately 54 : 10 in **F₂**, indicating that plants containing any two genes of **R**, **B** and **C** are all articulate.

Density of the Spike. BIFFEN (59, 70) showed that lax and dense ears give in **F₁** an intermediate condition, slightly denser than the

lax parent and produce in F_2 plants with ears as lax or dense as those of the parents, together with a series lying between these extremes, the proportion indicating that there is one main gene difference.

UBISCH (476, 663) considered the forms with rachis internode length of 3.5 mm. or longer as lax. With this grouping she obtained in F_2 a ratio of 3:1 for dense versus lax. There were indications, however, that in some crosses still other gene or genes were present which affected the degree of density.

HAYES & HARLAN (703) made a series of crosses. Manchuria (lax) $\times$ Svanhals (dense) gave in F_1 plants with ears as dense as the Svanhals parent, and the segregation in F_2 approximately in a 3:1 ratio. Pyramidatum (dense) $\times$ Jet (lax) gave in F_1 an intermediate form and in F_2 a continuous series of forms which reached beyond the parental forms. Breeding tests in F_3 indicated that the intermediate forms were all heterozygous. A single main gene is here concerned, which together with modifying genes, affects the expression of density. Hanna (lax) $\times$ Zeocriton (dense) gave different results. In F_2 a continuous series of variations with small gradations throughout the range from very dense to very lax, was obtained, in which homozygous forms apparently seem to exist, as was shown by the breeding behavior in F_3 . Several main genes for density are here involved, together with still minor genes.

Later MIYAKE & IMAI (939), in certain crosses, found a single gene difference between the lax ear and the dense ear, the lax being dominant.

IKENO (1156) states that there is a marked positive correlation between length of the awn and density of the spike. It was considered that this correlation most probably is due to pleiotropic effects of the genes for awn length, A and E.

OTHER MORPHOLOGICAL CHARACTERS

Dwarfishness. VESTERGAARD (665) made a cross between a dwarf-like variant and Binder barley. The F_1 plants consisted of 95 individuals, of which 81 were of the normal type like Binder barley, and 14 were of the dwarf form.

MIYAZAWA (820) found a dwarf type among the offspring of a back-cross by Golden melon barley on an F_1 of Golden melon $\times$ Sekitori. The dwarf type had tendency to dominate over the normal. The homozygous dwarfs were very small and sterile. In F_2 , sterile-dwarf to dwarf to normal was found in a ratio of 1:2:1.

On the other hand, a dwarf form found by HARLAN & POPE (1016) proved to be a simple recessive to the normal barley. This dwarf type measured only about 50 cm. from the crown of the plant to the tip of the awns, and was characterized by branching inflorescence and greatly increased number of nodes.

Chlorophyll Deficiencies. A number of chlorophyll defects have been found in barley. Several authors, NILSSON-EHLE (306), VESTERGAARD (375), KALT (451) and WIEBE (1232), all found that white seedlings behave as a simple recessive to the normal green. The white form is a true albino, depending on the failure of chlorophyll formation, and begins to die within a few weeks from emergence. Another albino type has been reported by Sô (842), which does not follow the Mendelian mode of inheritance, but is inherited maternally. He found further that a variegated type is a simple recessive to the normal form.

KIESSLING (558) discovered a mutant which differed strikingly from the parental variety in many characters, including the light green color of the foliage. This abnormal type is different monogenically from the normal dark green, the F_2 plants being obtained in a ratio of 1 normal to 2 intermediates to 1 abnormal. In another paper (559), he showed also that 'striped green' was dominant to the albino type, but hypostatic to the normal. Two green-leaved plants gave rise to 3 classes of offspring—green, striped and albino in a 12 : 3 : 1 ratio.

MIYAZAWA (821) found in one of the F_4 of Titurin $\times$ Golden melon barley, the segregation of green and light yellow plants in a ratio of 3 : 1. Evidently there is a single gene difference between the green and the yellow.

Six different chlorophyll defects were described by NILSSON-EHLE (942), albino (three forms), xantha (two forms) and chlorina. The xantha-type is characterized by a yellow seedling, and is not viable. The chlorina-type appears whitish-yellow at first, but later it gradually becomes greenish to some extent, so that the plant may mature under favorable cultural conditions. Evidence indicated that these three albinos are different genotypically, although similar in appearance; and the two xanthas differ phenotypically to a slight extent. Each of the abnormal types was a simple recessive to the normal in inheritance. In F_2 , albino $\times$ xantha gave green, xantha and albino; albino III $\times$ chlorina : green, chlorina, albino; and xantha I $\times$ chlorina : green, chlorina, xantha.

In addition to these forms described by NILSSON-EHLE, HALLQVIST (1014, 1148) obtained several other defect-types: albino IV, super-

chlorina, virescence (two forms), lutescence and 'Zwerg' (two forms). The superchlorina corresponds to the T-chlorina in *Allium* in appearance, but under favorable conditions it survives and produces grains. The virescence is a type similar to the virescent-white in maize. The lutescence-type is green at first, but later it becomes yellow and begins to perish. The 'Zwerg' is a peculiar type of chlorophyll-deficiency in that its expression is dependent on temperature. At 0° to 10° C. no chlorophyll develops, at 12° to 15° C. some green color develops, but the seedlings are very yellow, while at 20° C. the seedlings are normal green and develop vigorously, but are sterile, no ears being produced. These forms are all simple recessives to the typical green. HALLQVIST has assumed 13 genes for chlorophyll development—4 genes for albino types; 2 for each of xantha, virescence and 'Zwerg'; and 1 for each of chlorina, superchlorina and lutescence. It was also found that back crosses of the 'Zwerg' heterozygotes to the normal green gave results which differed according as whether the normal was used as the female or as the male parent. The results were explained by assuming a partial elimination of the male gametes which carry the recessive gene.

PHYSIOLOGICAL CHARACTERS

Fertility of the Lateral Florets. HARLAN ('18¹¹) classified the following four species of barleys on the basis of fertility of the lateral florets:

- 1) *H. vulgare* (6-rowed barleys)=Lateral florets fully fertile. Awn (or hood) development is quite similar for laterals and medians.
- 2) *H. intermedium* (6-rowed barleys)=Lateral florets partially fertile. The laterals never bear awns or hoods.
- 3) *H. distichon* (2-rowed barleys)=Lateral florets staminate.
- 4) *H. deficiens* (2-rowed barleys)=Lateral florets rudimentary. Two glumes and two diminutive paleae constitute the florets.

That the three forms, *vulgare*, *distichon* and *deficiens* are monogenically different from one another, as is shown by the following results, and give in F₁ an intermediate condition, has been reported by several authors, e. g., BIFFEN (59), GAINES (1331), KEZER & BOYACK (557), ENGLEADOW (690), MIYAKE & IMAI (939), KAJANUS & BERG (1165), HOR (1152), GRIFFEE (1257):

1) 'The identification of varieties of barley.' U. S. Dept. Agr. Bur. Plant Indust. Bull. 622, 32 pp.

$H. vulgare \times H. distichon \rightarrow F_2, 3 \text{ non-vulgare} : 1 \text{ vulgare};$

$H. vulgare \times H. deficiens \rightarrow F_2, 3 \text{ non-vulgare} : 1 \text{ vulgare};$

$H. distichon \times H. deficiens \rightarrow F_2, 3 \text{ distichon} : 1 \text{ non-distichon}.$

In the *vulgare* $\times$ *deficiens* crosses the lateral florets of F_1 are similar to those of *H. distichon*, but never breed true.

On the other hand, UBISCH (476) found in F_2 of the cross, *vulgare* $\times$ *distichon*, the ratio of 2-rowed to all others to be 3:13. The results were explained on a 2-gene basis. Gene **Z** was proposed for the 2-rows habit, and a modifying gene **W**, active only in the presence of **Z**, is required to produce the full reduction of awn size, and fertility characterizing the 2-rowed lateral floret. The 6-rowed forms are **zzWW**, **zzWw** and **zzww**, and can not be distinguished phenotypically from one another. The **ZZWW** and **ZZww** classes give only 2-rowed and intermediate forms respectively. In a later paper (1095), the same author reports that crosses of *deficiens* with 6-rowed gave normal 2-rowed plants in F_1 , and in F_2 2-rowed, 6-rowed and *deficiens* types in a ratio of 9:3:4. The following gene scheme has been established by her (**d**=gene for *deficiens*):

ZD normal 2-rowed,

zD 6-rowed,

(**Z**)**d** *deficiens*.

As regards the *intermedium* barley, ENGLEDOW (690) indicated a single gene difference between this form and the other three groups: *vulgare*, *distichon* and *deficiens*. From these results it was concluded that these four main groups of barleys were characterized by lateral floret forms which constituted a series of multiple allelomorphs.¹⁾

It is of great interest that HARLAN & HAYES (697) obtained from a cross, *vulgare* $\times$ *distichon*, a barley form belonging to the group *intermedium*. The parents used were Manchuria (a 6-rowed variety) and Svanhals (a 2-rowed variety). The F_1 was intermediate, viz. slightly fruitful and producing intermediately developed awns on the lateral florets. In F_2 a wide range of forms were obtained, in which some *intermedium* plants appeared. From the F_3 breeding test, the authors concluded that the Manchuria parent carried two genes for fertility of the laterals, one (**A**) for 6-rowed and one (**B**) for *intermedium*, which was hypostatic to the gene for 6-rowed. For these forms the following genic constitutions were suggested:

1) In a later paper (1134), however, ENGLEDOW obtained evidences against such a conclusion, but no other working hypothesis has been found to fit the case. See also under 'Linkage Relations'.

AB	<i>vulgare</i> (first form),
Ab	<i>vulgare</i> (second form),
aB	<i>intermedium</i> ,
ab	<i>distichon</i> .

There was evidence of another gene affecting lateral floret fertility.

SAUNDERS & MOE (1952) used an *intermedium* type, called Arlington awnless, as the female parent in a series of crosses. A monogenic difference was indicated between Arlington awnless and 6-rowed awned, giving in F_1 an intermediate condition, as shown in other crosses of this type by ENGLEADOW and others. Arlington awnless $\times$ 2-rowed hooded, however, gave considerably complicated results. The F_1 plants resembled Arlington awnless in the fertility of the lateral florets. F_2 progeny comprised four types, i.e. parental types, 6-rowed awnless and 2-rowed awned. The plants from the 2-rowed classes bred true in F_3 for the 2-rowed condition, while those from Arlington awnless type consisted of two genotypes, one breeding true for the type and the other giving Arlington awnless, 2-rowed awned and intermediates.

Recently IKENO (1969) reported an *intermedium* type which occurred as a mutant in the F_3 generation of crossing between two Japanese 6-rowed barleys, and behaved as a dominant when crossed with 6-rowed.

Winter vs. Spring Habit. According to TSCHERMAK (1906), spring barleys are dominant to winter barleys. Some winter forms were obtained by GAINES (1931) from crosses in which both the parental varieties were of spring habit. In F_2 of one cross, he obtained 18.75 per cent winter plants and 81.25 per cent spring plants. Two genes were assumed for explanation, one standing for the winter habit, the other inhibiting the winter habit. One of the parents was considered to carry both genes, and the other to lack both genes.

Later TAKAHASHI (1920) and SCHIEMANN (1906, 1902) obtained, from crosses of winter with spring varieties, a 3 : 1 ratio of spring to winter types in F_2 .

As regards winter-hardiness, SCHIEMANN found that it behaved as a rather complex character, but generally speaking, it was dominant to non-winter-hardiness. Gene **W**—probably **W**₁ and **W**₂—for winter-hardiness is independent of the gene **S** for spring habit. Various behaviors in F_3 and also later generations were explained by assuming the combination of these genes. The gene **W**₁ was considered to have twice the effect of **W**₂ on winter-hardiness. Plants possessing both genes **W** and **S** can develop normally, when sown either in the fall or in the

spring. The constant spring form is SSww, the constant winter form is ssWW.

Resistance to Disease. TSCHERMAK (1006) finds susceptibility to *Puccinia glumarum* (yellow rust) and to *Puccinia graminis* (stem rust) to have tendency to dominate over immunity.

Studies have been made by NILSSON-EHLE (727) on the inheritance of resistance to a nematode disease caused by *Heterodera schachtii*. The cross, Chavalier (immune) $\times$ Gold (susceptible), gave F_1 plants which were immune, and the segregation in F_2 , as determined by a test of F_3 , occurred in a 3:1 ratio.

HAYES *et al* (793, 1020) has studied the inheritance of the manner of reaction in barley to the spot blotch disease caused by *Helminthosporium sativum*. The results from a cross of a resistant variety with a highly susceptible variety showed that the susceptibility has tendency to be recessive to the resistance. It was pointed out further from F_2 , F_3 and F_4 breedings that the results could be explained on a 2-gene basis. Plants carrying both were highly resistant, while plants lacking them were highly susceptible.

Recently GRIFFEE (1257), from his cross of Svanhals (a highly resistant variety) with Lion (a highly susceptible variety), concluded:—“By studying the reaction of F_3 lines to this pathogene in relation to other characters the inference is drawn that at least three genes are concerned in the production of resistance of the type possessed by Svanhals”. (See also under ‘*Linkage Relations*’.)

OTHER CHARACTERS

As to the inheritance of other characters in barley, a short summary is given below in a tabular form (TABLE IX).

LINKAGE RELATIONS¹⁾

As seen in the foregoing review, considerable work has been done on inheritance in barley, but little has been done to establish the relation of these characters to one another. UBISCH (424, 476) found the gene concerned in fertility Z, to be linked with G, one of the genes for the toothing on the glume, with a crossover percentage of 16.7. In later studies (663, 849), she found further that three genes—L (gene for the

1) The haploid chromosome number in *Hordeum* is 7. (Vide TISCHLER, *loc. cit.*)

TABLE IX.—SUMMARY OF THE INHERITANCE OF SOME
CHARACTERS IN BARLEY.

Contrasted characters	F ₁	F ₂	Authors
<i>Height of Culm</i>			
Tall—short	Intermediate	1 tall: 2 interm.: 1 short	TSCHERMAK (1006)
Tall, slender—short, stout ('Udzu'-type)	Tall, slender	3 tall: 1 short	MIYAKE & IMAI (939)
According to UBISCH (664), height of culm is governed by one or more of three possible genes.			
<i>Spike</i>			
Normal—branched	Normal	3 normal: 1 branched	TSCHERMAK (1006)
Normal—giant	Normal	3 normal: 1 giant	VESTERGAARD (375,852)
The giant ears are mostly empty and mis-shapen, having only 6—7 very closely growing grains situated at the tip of the ear.			
Normal—bracteate	Normal	3 normal: 1 bracteate	MIYAKE & IMAI (939)
<i>Grain</i>			
Hulled—naked	Hulled	3 hulled: 1 naked	(BIFFEN (70) THATCHER (266) GAINES (1331) UBISCH (663) KAJANUS & BERG (1165), etc.
In the hulled condition the caryopsis is adherent to the lemma and palea at maturity, but in the naked condition the caryopsis remains free.			
Prickly—smooth dorsal veins	Prickly	3 prickly: 1 smooth	BLARINGHEM (108,760)
<i>Nutans</i> -base — <i>erectum</i> -base	<i>Nutans</i>	3 <i>nutans</i> : 1 <i>erectum</i>	SCHIEHMANN (1076)
The <i>nutans</i> barleys have the so-called 'smooth base,' while in the <i>erectum</i> barleys the base is deeply furrowed. The lodicule of the <i>nutans</i> is also different in shape from that of the <i>erectum</i> .			
<i>Vegetative Habit</i>			
Early—late ripening	Early		TSCHERMAK (1006)
Early—late heading	Early	3 early : 1 late	GRIFFEE (1257)

length of internode), **A** (gene for awn length) and **S** (gene for hulllessness)—lie in the same linkage group. The crossover values which she obtained for **LA**, **AS** and **SL** were 20%, 14.3% and 16.7% respectively. From these results she rejected the linear theory of the arrangement of genes in the chromosome.

That certain chlorophyll genes exhibit linkage was reported by NILSSON-EHLE (942). One of the genes for white seedlings (**C**) is linked with the genes for the chlorina (**F**). From the combination of **cF** × **Cf**, he obtained in F_2 green, chlorina and white plants in a ratio of 8.44 : 3.94 : 3.62 instead of the typical 9 : 3 : 4 ratio respectively. Instead of a 1 : 2 : 2 : 4 ratio in F_3 from green F_2 plants, a 0 : 9 : 12 : 126 ratio was found. It was suggested that allowing for a 10 per cent crossing over, the data would be in a better accord with the expectation.

MIYAKE & IMAI (939) have established two linkage groups, the members which belong to each group being as follows :

Group I. **N—n** : for hulled vs. naked grains,

$\left. \begin{array}{l} \mathbf{L_1-l_1} \\ \mathbf{L_2-l_2} \end{array} \right\}$: for the spike density,

A₁—a₁ : one of the gene pairs concerned in awn length,

C₁—c₁ : one of the gene pairs concerned in hooded vs. awned.

The crossover values for **A₁L₁**, **NL₂** and **NA₁** were calculated as 13%, 23% and 5% respectively.

Group II. **U—u** : for tall vs. short stature,

A₂—a₂ : one of the gene pairs for awn length,

I—i : for awnless vs. awned lateral floret,

D—d : for the fertility of the lateral floret,

P—p : one of the gene pairs for purple vs. colorless glume.

In the combination of **DI** × **di**, a monogenic segregation was obtained in F_2 , suggesting a close linkage between **D** and **I**. The linkage intensity between **U** and **D** was very low, showing almost independent segregation.

VAVILOV (851) found that in some cases the gene for rough awn and the gene for naked grain were linked, while in others they were not. He pointed out, too, the possibility of linkage relationships connected with the gene for the internode length of rachis.

ENGLEDOW (1134), by a careful study, indicated the possibility of an awn-lateral floret linkage in *H. hexastichum* var. *praecox* (6-rowed,

fully awned) $\times$ *H. inerme* (2-rowed, awnless). Although the F_2 ratio of 6-rowed fully awned to other types was in close agreement with 1:3, there were evidences against the monogenic mode of inheritance as follows: (1) a slight defect of the six-rowed and fully awned types in F_2 and later generations, (2) appearance of a few 'fully awned and 2-rowed' plants in one F_3 line, (3) appearance of a few awnless plants on which most of the laterals were fertile in F_3 .

Another linkage group was found by HOR (1152). He obtained results indicating that the genes concerned in the color of the grain (**B**), the texture of the awn (**R**) and the length of hairs on the rachilla (**L**) are located in the same chromosome. He pointed out, too, that the genes concerned in the hulled grain (**N**) and the extent of pubescence on the glume (**S**) are linked, with the possibility of one or more genes for density lying in the same group. The **NS** group was considered to be the same as the **LSA** group of UBISCH and group I of MIYAKE & IMAI.

A correlation was found by SCHIEMANN (1076) between the type of grain-base or lodicule (nutans- vs. erectum-type) and the vegetative habit (spring vs. winter).

Recently GRIFFEE (1257) reports that one of three genes concerned in the production of resistance to *Helminthosporium sativum* is linked with the gene for 2-rowed, the other gene with the gene for rough awn, and still another gene with the gene for white glumes. It was found further that the gene for early heading was linked with the gene for 6-rowed, with the intensity of 42 per cent crossovers.

Humulus lupulus

SALMON (310) made crosses between cultivated varieties of female plants and wild male plants, and obtained in F_1 some individuals differing from either parent (1) in their total inability to climb and (2) in their complete sterility. The proportion of 'fertile climbers' to 'sterile dwarfs' was different in various crosses, i.e. (1) 52:35, (2) 66:1, (3) 120:1, (4) 79:30.

Hyoscyamus niger

Flower Color. DE VRIES (8, 13, 56) made crosses between *H. niger annuus* and *H. niger pallidus*, and obtained a hybrid with the purple veins and central spot of corolla as in that of the former. CORRENS (28) found, however, that the same cross gave F_1 flowers of intermediate tint, the dominance being incomplete.

In a later paper (38), CORRENS mentioned that the presence of anthocyanin in the flowers in *H. niger* is completely dominant to its absence in *H. albus*.

Vegetative Duration. According to CORRENS (29, 38), biennial habit behaves as a dominant to annual, giving in F_2 a monogenic segregation.

Impatiens Balsamina

Flower Color. RASMUSON (417, 734) found that blue-red is the most epistatic color, and both pure red and pure blue are monogenically dominant to rose. Red and blue produce blue-red. White is recessive to blue-red, red and blue, and crosses between white and these colored forms give in F_2 some rose-colored segregates. The scheme of genes suggested for the flower color may be represented as :

ABR	blue-red,
AbR	pure red,
ABr	pure blue,
Abr	rose,
abr	white.

It was also found that white flecking on colored flowers is dominant to non-flecking, and depends on a single gene **F**.

Height of Plant. As to height of plant, RASMUSON (734) states that the cross tall (50–60 cm.) $\times$ low (20–30 cm.) gives F_1 plants nearer to the tall parent, and segregates in F_2 into various intermediate as well as the parental forms.

Ipomoea Batatus var. edulis

According to WADA (1097), green stem, white skin and white flesh are dominant to red stem, red skin and yellow flesh respectively, and the segregation seems to occur in a ratio of either 3 : 1 or 15 : 1.

Ipomoea imperialis

CORRENS (684) has worked with the chlorina and albomarmorata types in *Ipomoea imperialis*. Crosses between chlorina albomarmorata (white spotted pale green) and typica homogenea (normal green) gave in F_2 four phenotypes : typica homogenea, typica albomarmorata (white spotted green), chlorina homogenea (pale green) and chlorina albomarmorata in a ratio of 9 : 3 : 3 : 1. Three genes were assumed : gene **C**

stands for the chlorina pigment; gene **N** changes chlorina to normal green; and gene **H** produces solid leaf color as opposed to the spotted condition. The scheme of genes may be represented thus:

CNH	typica homogenea,
CNh	typica albomarmorata,
CnH	chlorina homogenea,
Cnh	chlorina albomarmorata.

Iris

BLISS (607), working with several varieties of bearded *Iris*, 'Maori King' (*variegata*), 'Cordelia' (*neglecta*), 'Thorbeck' (*amoena*), etc., showed that pigmented leaf base and brown tipped beard behave as Mendelian characters. It was noted, however, that in the coloring of the leaves there are some evidence indicating the presence of two or more cumulative genes, as well as red gene (**R**) and a blue gene (**B**). Besides these characters, some observations on flower color were also made in several crosses.

Lactuca mularis

DAHLGREN (536, 1123) made a cross, *L. mularis normale* × *L. mularis atropurpurea*, the former having normal green leaves, while the latter dark red ones. Green proved to be dominant to red, giving a 3:1 segregation in F_2 .

Lamium album

Two abnormal types have been investigated by SIRKS (1304). An abnormal form with peloric top flowers was crossed with the normal form which has zygomorphic flowers only. The F_1 plants were all normal. From F_2 generations and F_1 -R-back-crosses it was concluded that a number of multiple genes — four at least, possibly five or even more —, each of them producing the normal form of inflorescence, may be present in normal plants.

Another abnormal type with protruding stamens is very similar in genotypic character to the peloric type. The results of crossing indicate that the aberrant form is recessive and the normal plants used possessed at least four dominant multiple genes.

Lamium maculatum

SIRKS (1304). An abnormal type in which the lower lips of the flower are reduced to a small lobe, is a character monogenically recessive to the normal type.

Lappa

According to HERIBERT-NILSSON (134), the brown color in the involucral bracts (*L. tormentosa*) differs by a single gene from the green (*L. officinalis*), the former being dominant.

Lathyrus odoratus•
COLOR INHERITANCE

Flower Color and Pattern. BATESON, SAUNDERS & PUNNETT (47, 57, 87) and especially PUNNETT (947, 1067) have fully worked on the color inheritance in the Sweet Pea. In each of the following cases a monogenic difference was found, the dominant characteristic being mentioned first:

- 1) White—cream,¹⁾
- 2) Colored—white,
- 3) Purple—red,
- 4) Bright—dull color,
- 5) Full—dilute color,
- 6) Light—dark wings,
- 7) Purple—copper,
- 8) Purple—maroon.

The cream is due to colored plastids; the other colors are all sap colors.

From the fact that two white strains, phenotypically identical, when crossed together, gave a 'Purple Invincible' hybrid with chocolate standard and bluish purple wings (BATESON, SAUNDERS & PUNNETT, 47), it may be inferred that the production of anthocyanin is dependent on the co-existence of two complementary genes, **C** and **R**.

1) M. G. & D. THODAY (148) suggest, however, that three recessive genes are concerned in the cream color. The first gene stands for yellow plastid, the second for yellow sap (!) and the third for an excess of yellow plastid. The depth of the cream may vary according to different combinations of these genes.

The purple class (Purple Invincible, Lord Nelson, Robert Felton or Picotee) carries a bluing gene **B** in addition to **C** and **R**, while in the red class (Painted Lady, Miss Hunt, Tinged White, Robert Sydenham or Tangerine) it is absent.

The other genes, **D** for bright color, **De** for full color, **L** for light wings and **J** for purple as opposed to copper, act as modifiers both for the purple (**B**) and for the red class (**b**). The gene **D** causes, for example, the difference between a color as ordinary purple and a blue such as in Lord Nelson; the gene **De** causes the difference between ordinary purple and Picotee, or that between ordinary red and tinged white. The gene **L** similarly causes the difference between Purple Invincible (with blue wings) and the corresponding form with purple wings, and also that between Painted Lady (with pinkish white wings) and the corresponding form with red wings. The gene **J** manifests itself most evidently in the case involved in the ordinary Purple Invincible. The loss of this gene from the latter produces a form in which the standard is deep copper and the wings, instead of being blue, are bright copper pink. At the same time, this gene brings about a change in the general appearance of the plants. Red-purples (**j**) are always smaller in height than normal (**J**), reaching on the average to about 2/3 of the height of the latter.

Thus as regards pigmentation, the varieties may be broadly classified into the following series :

CRBJ	purple series,
CRBj	red-purple series,
CRbJ	red series,
CRbj	red-red series,
Other combinations without C or R . . white or cream.	

By the color of the flowers, however, the red-reds can not be distinguished from the true reds, but in strains where these two types occur together, they can be distinguished from each other by the general appearance of the plants.

There is another modifying gene for flower color, **E**, which stands also for the erect form, as opposed to the hooded form, of the standard. Where the standard is erect (**E**), its color is deeper and brighter, and markedly bicolor than in corresponding hooded form (**e**). Thus as to the purple group, the following 16 color varieties are known :

Purple Series

ELDJ . . Purple Invincible (P.I.);
EIDJ . . Deep Purple (Ppw),
eLDJ . . Duke of Westminster (D.W.),
eIDJ . . Duke of Sutherland (D.S.),
ELdJ . . Blue bicolor,
EldJ . . Deep blue,
eLdJ . . Blue hood,
eldJ . . Lord Nelson,

Red-purple Series

ELDj . . Red P.I.
EIDj . . Red Ppw.
eLDj . . Red D.W.
eIDj . . Red D.S.
ELdj . . Violet bicolor.
Eldj . . Deep violet bicolor.
eLdj } . . Violet Duke.
eldj }

Corresponding to each self-colored form, there is a recessive 'white-marbled' form. PUNNETT (1067) found that this form is always accompanied by the light axil. Marbled $\times$ R-white always gives a marbled F_1 . Self-colored plants which throw R-whites do not throw marbled, while those that give marbled do not give any R-whites. These results suggest that self-color, marbled and R-white behave as a series of multiple allelomorphs. It was also found that marbled $\times$ C-white gives self-colored F_1 , and both marbled and white in F_2 .

As to the patching, PUNNETT (947) showed that all plants showing this mosaic pattern in the flowers are heterozygous, producing normal, patched and red flowers in varying proportions. The inheritance of patching in the Sweet Pea was thought to be possibly analogous to cases of flaking in *Mirabilis* and *Primula*, variegation in *Zea*, and striping in *Antirrhinum*.

In addition to these, there are some further characters which have not been so fully analyzed. The flaked Sweet Peas such as 'Senator' or 'America' are probably recessive to a corresponding self-colored purple or red. Mauve flower color is recessive to purple. According to M.G. & D. THODAY (148), a scarlet color is a distinct form and is recessive to the bluish-pink of the 'Painted Lady' form.

Axil Color. BATESON, SAUNDERS & PUNNETT (47, 57). The appearance of a reddish purple spot in the axils of the leaves is due to the presence of one dominant gene. When this gene is present the axils are dark and the flowers colored; when it is absent the axils light (= green) and the flowers white.

STEM and LEAF CHARACTERS

Growth Habit. BATESON (106), BATESON, SAUNDERS & PUNNETT

(15, 47, 57). As regards the habit of growth, the following two allelomorphs have been studied :

- 1) Tallness—dwarfishness.
- 2) Prostrate, non-branching—erect, branching habit.

The dwarf or 'Cupid' is characterized by its short internodes. Its foliage color is deeper green than that of the normal. The erect, branching form is called 'Bush' and attains to a height of about 3 feet. The cross, 'Cupid' $\times$ 'Bush', gives a reversionary form exactly like the normal tall variety. A scheme of the genes may be represented as :

TP tall,
 Tp 'Bush,'
 tP 'Cupid,'
 tp 'Bush-Cupid.'

Pubescence. PUNNETT (1067). A variety was found, in which the stems are quite smooth, lacking the short stiff hairs which give a rough feel to the stem of the normal Sweet Pea. This character is particularly noticeable in the young pods. Glabrousness differs by a single gene from pubescence, the latter being dominant.

Acacia Type of the Leaf. PUNNETT (1067). In the acacia-leaved Sweet Pea, leaflets take the place of the tendrils. In this case dominance is generally incomplete, heterozygous plants always showing an occasional leaflet replacing a tendril. In F_2 tendrillar plants, high grade intermediates and acacias occur in a ratio of 1 : 2 : 1.

FLOWER CHARACTERS

Flower Form. Concerning this character, the following four allelomorphs have been studied :

- 1) Erect—hooded standard. BATESON, SAUNDERS & PUNNETT (57), BATESON (106).
- 2) Normal—cretin flower. BATESON & PUNNETT (154, 155, 156), PUNNETT (510).
- 3) Normal—snapdragon flower. BATESON, SAUNDERS & PUNNETT (47).
- 4) Clamped—open keel. PUNNETT (1067).

In the hooded variety, the vexillum lacks the well marked central notch, characteristic of the erect variety. In certain strains in which both red and purple plants occur, the hood is always associated with the latter

color. The cretin flower is caused by an abnormal development of the stigma and petals. It is completely sterile on the female side, though it may produce normal pollen grains. The snapdragon flower, perhaps an extreme form of hood, resembles an *Antirrhinum* flower. The clamped keel is the ordinary form found in the wild Sweet Pea and in all varieties with the non-waved type of standard. The open keel is characteristic of the more modern type of flower with the waved or 'Spencer' standard.

Pollen Shape. BATESON, SAUNDERS & PUNNETT (47), BATESON (106). The characters 'long pollen' (with three pores) and 'round pollen' (with two pores) usually behave as ordinary plant characters, the difference being monogenic, long grains being dominant. Long grains are occasionally found on 'round' plants, but as yet only one plant bearing round pollen has been found to give any 'long' plants on self-fertilization.

Anther Sterility. BATESON, SAUNDERS & PUNNETT (47), GREGORY (53). The sterile conditions of anthers which is due to an abnormal behavior of chromosomes is recessive to the fertile. Plants showing anther sterility are normal and fertile on the female side.

LINKAGE RELATIONS

PUNNETT (1067) adopts MORGAN's view, rejecting the reduplication hypothesis (154, 155, 156, 309, 510). Up to the present, five different linkage groups have been clearly established. The members of each group are as follows:

Group A.

- $$\begin{cases} A_1-a_1 : \text{purple—red} (=B-b \text{ of earlier papers}). \\ A_2-a_2 : \text{long—round pollen} (=L-l \text{ of earlier papers}). \\ A_3-a_3 : \text{erect—hooded standard} (=E-e \text{ of earlier papers}). \end{cases}$$

The order of the genes: $A_2-A_1-A_3$.

The number of crossovers between A_1 and A_3 equalled 1%, and between A_1 and A_2 about 12%.

Group B.

- $$\begin{cases} B_1-b_1 : \text{dark—light axil} (=D-d \text{ of earlier papers}). \\ B_2-b_2 : \text{fertile—sterile anthers} (=F-f \text{ of earlier papers}). \\ B_3-b_3 : \text{normal—cretin flowers} (=N-n \text{ of earlier papers}). \end{cases}$$

The order of the genes: $B_3-B_1-B_2$.

The data indicate that B_2 and B_3 are about 25 units apart on the

chromosome, while B_1 lies 6 units apart from B_2 , between the latter and B_3 . Some evidence was also obtained suggesting a linkage between maroon (b_4) and light axil, but the numbers were too scanty to determine its value.

Group D.

$\{D_1-d_1$: normal—acacia type.
 D_2-d_2 : bright—dull color.

Of crossovers there were about 33%.

Group F.

$\{F_1-f_1$: colored—R-white (=C—c of earlier papers).
 F_2-f_2 : procumbent—bush (=P—p of earlier papers).
 F_3-f_3 : self-colored—marbled.

The genes F_1 and F_3 occupy the same locus on the chromosome (see under 'Flower Color'). F_2 is about 25 units distant from this locus.

Group G.

$\{G_1-g_1$: colored—C-white (=R—r of earlier papers).
 G_2-g_2 : purple-red—purple.

The data indicate a crossover value of about 25% between G_1 and G_2 .

There are other characters investigated which behave as if they were independent, i.e.

C—c : hairy—glabrous.

E—e : tall—cupid (=T—t of earlier papers).

H—h : closed—open keel.

Thus the total linkage groups seems not to be less than eight. PUNNETT (1295) states that "further experiment must decide whether the chromosomal number (=7) can be reconciled with the number of the groups of characters shewing independent inheritance."

Linaria alpina

SAUNDERS (261) reports that the pink flower color of the variety *rosea* is recessive to the blue color occurring in the type and in the variety *concolor*; and as regards palate character, the presence of orange in the type and in var. *rosea* is recessive to its absence in var. *concolor*.

Linaria moroccana

CORRENS (1329) made a cross between red-flowered and white-flowered strains. It gave blue in F_1 , and in F_2 blue, red and white in a ratio of 9:3:4. Two genes were assumed, one for production of anthocyanin, its absence having no effect, and the other for alkalinity

of cell sap, its absence resulting in acid sap. The alkaline sap was supposed to have bluing effect, and the acid sap reddening effect.

Linaria vulgaris

Flower Color. SAUNDERS (261). The presence of orange colored area in the palate is dominant to its absence. In *L. alpina* the case is exactly the opposite.

Self-sterility. CORRENS (434) found that the offspring of a cross between two self-sterile plants consists of four classes, all inter-fertile and intra-sterile, except that class IV was fertile with class II when used as a male parent, and sterile when used as a female. The genic analysis has not yet been reached.

Linum

Flower-, Anther and Seed-Colors. A great number of crosses have been made with respect to the co-operation of genes for various characters in *Linum usitatissimum* (TAMMES, 206, 373, 422, 471, 589, 962, 1085). The results obtained indicated that six genes: **A**, **B'**, **C'**, **D**, **E** and **F** are involved in the color of the petal (See TABLE X). Of these genes **B'** and **C'** are the basic genes for the color, and produce extremely light pink, hardly distinguishable to the eye from white.¹⁾ **A** and **E** are intensifying genes, and act accumulatively in each other's presence. The action of **E** is stronger than that of **A**.²⁾ **D** modifies the pink color produced by **B'** and **C'** into lilac, and acts also as an intensifying gene. The inter-relation between **A** and **D** is peculiar. In the presence of **B'**, **C'**, **D** and **F**, **A** dominates over **a**, while in the presence of **B'**, **C'** and **F**, **a** dominates over **A**. **F** has no appreciable effect without **D**, but it changes the lilac into blue. **F** acts simultaneously as a diluting gene.

Thus we have the following scheme of genes for the flower colors:

B'C'DF	blue,
B'C'Df	lilac,
B'C'dF	pink,
B'C'df	pink,
Other combinations . . .	white.

1) When **C'** is homozygous together with **B'**, the veins of the petal are darker than the rest of the petal. When **C'** is heterozygous in the presence of **B'**, the petals are 'without veins', namely the darker color of the veins is wanting. See TABLE X.

2) For example, blue—**A**=light blue, blue—**E**=pale blue.

TABLE X.—INHERITANCE IN FLOWER OF *Linum usitatissimum*.

A summary of results obtained by TAMMES (962).

Contrasted colors	F ₁	F ₂
Common blue—lilac	Common blue	3 blue : 1 lilac
Light blue—lilac	Common blue	9 common blue : 3 light blue : 3 lilac : 1 light lilac
Common white—lilac	Common blue with- out veins	Common blue : blue without veins : $\underbrace{\quad 3 \quad \quad \quad 6 \quad}_{9}$ lilac : lilac without veins : white $\underbrace{\quad 1 \quad \quad \quad 2 \quad}_{3} \quad \quad \quad 4$
Lilac—crimped white	Common blue	9 blue : 3 lilac : 4 crimped white (ac- tual numbers=411 : 141 : 158)
Common blue (blue anther)—pale-blue (yellow anther)	Common blue (blue anther)	3 common blue (3 blue anth. : 1 yellow anther) : 1 pale blue (3 blue anther : 1 yellow anther)
Lilac (blue anth.)—pale blue (yellow anther)	Common blue	Common blue, pale blue, lilac, pale- lilac (The proportion was not deter- mined).
Crimped white (yellow anther)—pale blue (yellow anther)	Common blue (blue anther)	9 common blue (3 blue anther : 1 yel- low anther) : 3 pale blue (3 blue anther : 1 yellow anther) : 4 crimp- ed white (4 yellow anther)
Common blue (blue anther)—pink (yel- low anther)	Common blue (blue anther)	3 common blue (blue anther) : 1 pink (yellow anther)
Light blue (blue anth.) —pink (yellow anth.)	Common blue (blue anther)	9 common blue (blue anther) : 3 light blue (blue anther) : 3 pink (yellow anther) : 1 light pink (yellow anth.)
Pale blue—pink	Common blue	9 common blue : 3 pale blue : 3 pink : 1 pale pink
Lilac—pink	Common blue	9 common blue : 3 lilac : 3 pink : 1 dark pink
Common white (yellow anth.)—pink (yellow anther)	Common blue (blue anther)	9 common blue (blue anther) : 3 pink (yellow anther) : 3 white (blue an- ther) : 1 white (yellow anther)
Crimped white (yellow anth.)—pink (yellow anther)	Common blue	9 common blue (blue anther) : 3 pink (yellow anther) : 3 crimped white (yellow anther) : 1 common white (yellow anther) (actual numbers= 509 : 164 : 117 : 40).

For the intensity of the color, there are 16 possible cases, which may be divided into three groups, viz. a group of eight kinds of pink flowers, a group of four kinds of lilac flowers and one of four kinds of blue flowers. For example, the members of the lilac group may be represented as :

B'C'DfAE lilac,
B'C'DfaE light lilac,
B'C'DfAe pale lilac,
B'C'Dfae vary pale lilac.

The slightest intensity is shown by **B'C'dFae**, being even slighter than that caused by the basic genes alone.

As to the color of the anthers, three genes **B'**, **D** and **H**, were shown to be necessary for the production of blue ; if one of these is absent the anthers are yellow. Consequently blue and lilac-colored flowers have either light or dark anthers, and likewise white flowers may have blue or yellow ones, and pink flowers only yellow ones.

The inheritance of seed coat color involves the genes **G**, **D** and **B'**. **G** is the basic gene, and produces the brown color. If **G** is absent the seed coat is colorless and transparent, and the seed yellow, which is due to the yellow color of the cotyledons. **D** inhibits the action of **G**, and produces—in the presence of **G**—the grayish-green color. **B'** neutralizes the inhibitory action of **D**, and itself has no direct effect on color production. Thus the various cases, may be represented as :

GDB' brown,
GDb' grayish-green,
GdB' } brown,
Gdb' }
Absence of **G** yellow.

For the flower-color intensity, TAMMES found further that there are three series of multiple allelomorphs, each series concerned with four genes.

Further a peculiar mode of inheritance has been reported by him of the interrelation between the shape of petals and the color of flowers, anthers and seeds. A cross between a normal (broad-petalled) white-flowered variety with blue anthers and brown seeds (**B'B'c'c'DD** . .) and a narrow-petalled crinkled white variety with yellow anthers and green seeds (**b'b'C'CDD** . .) gave normal blue-flowered F_1 plants with

blue anthers and brown seeds. In F_2 the following four phenotypes were obtained :

- Normal blue plants with blue anthers and brown seeds ($B'C'D$),
- Normal white plants with blue anthers and brown seeds ($B'c'D$),
- Crinkled white plants with yellow anthers and green seeds ($b'C'D$),
- Normal white plants with yellow anthers and green seeds ($b'c'D$).

In this case, however, a certain deviation from the theoretical 9 : 3 : 3 : 1 ratio was found, which consists in a deficiency of crinkled whites. (See also : Crinkled white $\times$ lilac or pink in TABLE X). These facts were explained on the assumption that, acting together with D , but in the absence of B' , C' causes the crinkled condition of petals, and acts simultaneously as a semi-lethal gene.

Recently, KAPPERT (1277) and SYLVÉN (1309) report another new crinkled white variety which has yellow anthers, but brown seeds. This new form behaves as a simple recessive to normal blue. In crossing with the normal white variety (with blue anthers and brown seeds), KAPPERT obtained blue F_1 plants and a dihybrid segregation in F_2 , namely, 9 normal blues : 7 whites (of which 3 are normal with blue anthers, 3 crinkled with yellow anthers, and 1 normal with yellow anthers). In crosses with the crinkled variety with grayish-green seeds, this new variety gave similarly blue F_1 plants, which showed the segregation in F_2 into: 9 blues : 3 crinkled whites with brown seeds : 4 crinkled whites with grayish-green seeds. From these results, KAPPERT assumed a third basic gene for the color, in addition to the two genes assumed by TAMMES. These genes were now designated as B_1 , B_2 and C' . The genic scheme concerning these three different white varieties may be given as follows :

- B_1B_2c' Common white variety,
- b_1B_2C' Crinkled white variety with green seeds,
- B_1b_1C' Crinkled white variety with brown seeds.

The results obtained are clearly explained on the assumption that (1) the crinkled condition is caused by C' , in the absence of either B_1 or B_2 , (2) the presence of both B_1 and B_2 is necessary to produce the blue color in the anthers, and (3) the presence of B_1 is necessary to cause the brown seed coat color.

Besides these crinkled whites, TAMMES found another type with blue anthers and brown seeds in F_2 of a crossing of a broad-petalled white variety of *L. usitatissimum* with the wild flax, *L. angustifolium*.

Taking the results obtained in the cultivated flax as a basis,

TAMMES postulated a series of similar genes in *L. angustifolium*. In this case also, seven genes—**A^a**, **B^a**, **C^a**, **D**, **E**, **F^a** and **H**—have been determined for the color of the petals and other parts. Their genetical behaviors are very similar to those met with in the cultivated variety. Some differences, however, have been recognized, e.g., **B'**, **C'** and **F** give a darker shade than **B^a**, **C^a** and **F^a**.

Size Characters. In the wild *angustifolium*, the seeds are smaller than those of the cultivated species. With respect to length of seed, TAMMES (206) made several crosses of the wild and cultivated varieties as well as crosses between cultivated varieties. The F_1 plants had seeds of intermediate size, and showed a continuous segregation in F_2 . The results obtained indicated that some multiple genes (from two to four) are involved in length of seed.

Length and breadth of petal were also studied. Following four varieties were used :

- A. An Egyptian cultivated blue-flowered flax, its petal having a mean breadth of 13.4 mm.
- B. The common blue flax, with a breadth of 7 mm.
- C. The common white flax, with a breadth of 7.1 mm.
- D. A small-petalled white variety, with a breadth of 3.3 mm.

The cross $B \times C$ showed segregation for flower color in F_2 , but the breadth of petals remained unchanged. In the crosses $A \times C$ and $A \times B$, the F_1 plants showed intermediate size of the petals, and in F_2 segregates ranged from one parent to the other. From the former cross it was found that the genes for color of flower and seed and for size of seed are apparently inherited independently. Several homomeric genes for size of petal were assumed to explain the results. The crosses of **D** with other forms gave peculiar results. $B \times D$ gave normal segregation for flower color in F_2 , but all blue-flowered segregates agreed in size with the blue parent, and all white segregates had small-sized petals. $A \times D$ gave in F_1 blue-flowered plants with petals of intermediate size. In F_2 segregation for flower color occurred normally, but the blue-flowered segregates gave a larger average breadth of petal than the white segregates.

These results were explained on the assumption that breadth of petal is influenced by **B'**, **C'** and **D**. **C'** and **D** act as inhibitory genes for flower size but only conjointly. If one or both are absent, the petal is normal in breadth. **B'** neutralizes the inhibitory action of the complex **C'D**. Thus only in one of the eight possible cases, **b'C'D**, the

petal becomes narrow, the other combinations resulting all in the normal breadth.

Capsule Characters. In the wild *angustifolium*, the edges of the septa of the capsule are ciliated, and the capsules open at maturity, while the cultivated flax has the naked septa and the closed type of capsule. BLARINGHEM (757, 873) and TAMMES (206, 422) found a monogenic difference between ciliated and naked races, the ciliated condition being dominant. The open type of capsule was found by TAMMES to be incompletely dominant, i.e., the capsules of F_1 plants did not open as widely as in the wild flax. Homozygous open and homozygous closed lines were produced in later generations. Several multiple genes are necessary to explain the results.

Resistance to Disease. TISDALE (515) made several crosses of the inheritance of wilt (*Fusarium lini*) resistance in *L. usitatissimum*. In a cross, resistant $\times$ susceptible, he obtained the resistant F_1 plants. In F_2 , from a total of 530 plants 162 were resistant and 368 susceptible. He says that "these figures approach very closely the expectation, if four factors are concerned in producing resistance." Except for this case, however, no definite dominance or ratios could be detected. Some crosses gave in F_1 entirely susceptible plants, while from others F_1 plants were intermediate. The lack of uniformity of results may be partly explained by varying environmental conditions which influence the degree of resistance to a considerable extent.

Lunaria annua

According to CORRENS (110), white-margined (*albomarginata*) leaves are recessive to the normal green, and the F_2 segregation is normal.

Lupinus angustifolius

Color of Flower and Seed Coat. KAJANUS (249) found that in *L. angustifolius* blue color of flower was accompanied by dark seed coat color, while white flowers by whitish seed color. Dark marbling was found to be dominant to pale.

FRUWIRTH (624) observed spontaneous variation in color of seed coats of a spotted strain of narrow-leaved lupine. This variation was a dilution of the color. Reciprocal crosses between this dilute-colored form and the parental strain yield different results. When the maternal parent was dilute, dilute color was dominant in F_1 , while when the

paternal parent was dilute, it behaved as a recessive character. Both hybrids showed segregation in F_2 and later generations, but behavior was very irregular.

VESTERGAARD (665, 852) recognized a monogenic difference between blue and white, blue and red, red and white in the flower. Some crosses of red and white, gave blue in F_1 , and 9 blues to 3 reds to 4 whites in F_2 . Two genes, **B** and **R**, were assumed.

Later HALLQVIST (789) analyzed in detail the genes in various color varieties of the lupine. From the results obtained (tabulated in TABLE XI), he identified five genes concerned in flower- and seed-color.

R: the basic gene for color, producing by itself pure red flower color and rust-brown seed color; its absence results in white flowers and white seeds.

B: a bluing gene giving bluish red flowers and earth-brown seeds in presence of **R**.

V: a gene converting red into violet; **V** has no effect on the seed color.

F: a gene necessary for the complete development of the color, its absence resulting in dilution of the color, but having no effect on the seed color.

Thus we get:

	<i>Flower</i>	<i>Seed</i>
RBVF	blue	earth-brown,
RBVf	tinged blue	„ „
RBvF	bluish red	„ „
RBvf	tinged red	„ „
RbVF }	violet	rust-brown,
RbVf }		
RbvF }	pure red	„ „
Rbvf }		
r(BVF)	white	white.

In addition to these genes, another was found: **M**, the marbling gene.

Still later, ROEMER (1071, 1205) announced that the black mark on the hilum is dominant to its absence, showing segregation in F_2 in a monohybrid ratio.

Recently SYPNIEWSKI (1310) partly confirms HALLQVIST's results, having obtained a monogenic difference between blue and white, blue and violet, violet and white, and a digenic difference between blue and white (9 blue : 3 violet : 4 white in F_2).

*Linkage Relations.*¹⁾ HALLQVIST (789) reports that the genes, **B** for blue, **V** for violet and **F** for color intensity, form a linkage group. The linkage between **B** and **F** is very close, if not complete. The other linkage value (**B—V** and **F—V**) represents a crossover percentage of about 22%.

Further, ROEMER (1205) found that marbling in the seed is closely correlated with the light blue color of the flowers.

TABLE XI.—A SUMMARY OF RESULTS OBTAINED BY HALLQVIST (789),
CONCERNING THE INHERITANCE OF FLOWER- AND SEED-
COLOR IN *Lupinus angustifolius*.

Contrasted colors	F ₁	F ₂	Genes involved
fl.=flower ; sd.=seed.			
1. White fl., white sd.— blue fl., earth-brown sd.	blue fl., earth- brown sd.	3 blue : 1 white	R
2. Violet fl., rust-brown sd.—blue fl., earth- brown sd.	blue fl., earth- brown sd.	3 blue : 1 violet	B
3. Bluish red fl.—blue fl.	blue	3 blue : 1 bluish red	V
4. Tinged blue fl.—blue fl.	blue (somewhat paler than the parent)	3 blue : 1 tinged blue	F
5. White fl., white sd.— tinged blue fl., earth- brown sd.	slightly diluted blue fl., earth- brown sd.	9 blue : 3 tinged blue : 4 white	R and F
6. Violet fl., earth-brown sd.—white fl., white sd.	blue fl., earth- brown sd.	9 blue : 3 violet : 4 white	B and R
7. Bluish red fl., earth- brown sd.—white fl., white sd.	blue fl., earth- brown sd.	9 blue : 3 bluish red : 4 white	V and R
8. Tinged blue fl., earth- brown sd.—violet fl., rust-brown sd.	slightly diluted blue fl., earth- brown sd.	1 violet : 2 blue : 1 ting- ed blue	B and F close- ly linked
9. Bluish red fl., earth- brown sd.—violet fl., rust brown sd.	blue fl., earth brown sd.	blue, violet, bluish red and pure red	V and B par- tially linked
10. Bluish red fl.—tinged blue fl.	slightly dilute blue	blue, tinged blue, bluish red and tinged red	V and F par- tially linked

1) The haploid chromosome number in *Lupinus angustifolius* is 20. (Vide TISCHLER, *loc. cit.*)

Other Species of Lupinus. KAJANUS (249) dealing with *L. luteus* showed that the black color in the seed coat is dominant to gray, and rich marbling to partial marbling. In a later paper (350), he states that in *L. mutabilis* blue flowers are dominant to white, showing segregation in F_2 in a monohybrid ratio.

BURLINGAME (764) worked at *L. apricus vallicola*, *L. pipersmithii* and *L. nanus*. Plants with striped white flowers gave rise to dark blues, striped whites and some whites. It was stated that striped whites probably are hybrids between white and dark blue, and the difference of these two types is monogenic. Plants with light blue flowers gave rise to light blue plants only, or 3 light blue to 1 dark blue plants, indicating that the light blue color is due to a dominant gene. Dark seeds are correlated with dark blue flowers, but are probably due to separate genes.

Lychnis

Flower Color. Some earlier observations on color inheritance were made by DE VRIES (8, 65), SAUNDERS (15) and CORRENS (28). DE VRIES has recognized a monogenic dominance of red over white, whilst the two other authors have not observed any clear segregation of color.

SHULL (101) made a cross between white- and purple-flowered varieties of *L. dioica*. The purple proved dominant to the white. In a later paper (144), he detected the two types of purple, one becoming blue when treated with alkalis, and the other changing to red on the addition of weak acids. The former (bluish-purple) was found to be hypostatic to the latter (reddish-purple), this being the reverse of the condition found in other plants. Two genes, **B** and **C**, were assumed for formation of the bluish-purple, and a third gene, **R**, for the reddish-purple. Thus the scheme of the genes may be:

RBC	reddish-purple,
rRC	bluish-purple,
RbC, RBc, Rbc, etc.	white.

Later SHULL (265) used two new German strains, *Melandrium album* and *M. rubrum*. A white-flowered form (*album*), when crossed with the purple-flowered form (*rubrum*) gave 23 white- and 4 purple-flowered offspring. A certain individual of *album* crossed with white *dioica* gave reddish-purple offspring in F_1 , in other crosses white-flowered offspring only.

Leaf Size. The discovery by BAUR (217) of a narrow-leaved mutant (*angustifolia*) in *dioica* has led to the demonstrations that the relatively broad leaves of the normal or 'typica' form is a sex-linked character. Broad leaf proved dominant to narrow leaf, and gave segregation in F_2 in a 3:1 ratio, the recessive type reappearing only in half the males.

Later SHULL (369) made a complete analysis of the F_2 plants, and showed that all of the broad-leaved males were heterozygous for the broad-leaf gene, and the half of the females were homozygous and half heterozygous for the same gene. If **F** represents the sex-gene (females being **FF**, and males **Ff**) and is completely linked with **B**, the broad leaf gene, we get in F_2 of crosses between typica females, **FBFB**, and narrow-leaved males, **Fbfb**, the following four combinations:

FBFB broad-leaved homozygotes ♀,
FBFb broad-leaved heterozygotes ♀,
FBfb broad-leaved heterozygotes ♂,
Fbfb narrow-leaved homozygotes ♂.

Chlorophyll Deficiencies. BAUR (157) described a wild *Melandrium album* which had one branch with white-edged leaves, forming a periclinal chimera. A female flower on this branch was crossed with pollen from a normal green plant. The F_1 plants were all green, and in F_2 green and white offspring was produced in a 3:1 ratio. Thus the original cross was equivalent to the cross, white × green. He assumed a gene **Z** for chlorophyll development, its absence resulting in pure white seedlings which are nonviable.

The existence of this gene was later confirmed by SHULL (367). He also further dealt with two pale green varieties, so-called 'pallida' and 'chlorina.' The chlorina plants have about 43 per cent of the normal chlorophyll. But it is very variable in color, and also has a tendency to fade in strong sunlight, especially near their centers. The pallida type is rather darker in color having about 65 per cent of the normal chlorophyll content, and is more uniform than in chlorina. It does not fade in sunlight. Crossing experiments showed that these two types are simple recessives to the normal type, and the cross of pallida × chlorina gives green F_1 plants, and in F_2 green and pale green offspring in a 9:7 ratio. The following genes were assumed: **X** for the unknown gene complex necessary for chlorophyll development, **z** for albino, **y** for pallida, and **n** for chlorina.

Thus:

XZYN	dark green (typica),
XzYN	albino,
XZyN	pallida,
XZYn	chlorina,
XZyn	subchlorina.

The last type, however, could not be distinguished from the others.

BAUR inclines to the opinion that the gene **Z** is concerned in the production of the yellow pigment (carotin). SHULL, however, on the basis of his experiments, believes that **Z** has no connection with the inheritance of carotin.

Other Characters. DE VRIES (8, 65) crossed *L. dioica* and *L. vespertina* with a glabrous form of the latter. The results showed that the hairy character is dominant to the glabrous condition, a single gene being involved. A similar result was also obtained by SAUNDERS (15).

The teeth of the capsules, on dehiscing, curves outwards in *L. dioica*, while *L. vespertina* lacks this habit. According to DE VRIES (65), the curved condition is monogenically dominant to the straight, and independently inherited of flower color (red vs. white) and pubescence.

Lycopersicum esculentum

A number of clearly segregating characters are known in the tomato. Below is given a summary of the inheritance of these characters in a tabular form (TABLE XII).

*Linkage Relations.*¹⁾ According to JONES (497), the data of HEDRICK & BOOTH (75) and PRICE & DRINKARD (99) show linkage relations between the genes for stature and fruit shape and also between those for leaf color and loculation of ovary.

CRANE (387) suggests that a linkage exists between general fruit shape (not pyriform) and certain types of inflorescence.

LINDSTROM (1188), in F_2 of the cross of **RRYY** $\times$ **rryy**, showed that the types with colorless skin are consistently heavier than those with the yellow skin, whether the fruit is red or yellow in flesh color, indicating that the gene **Y** is associated with large size of fruit. He observed further that the **Yy** genes are linked with the genes for loculation of ovary and also those for time of flowering.

In a later publication (1286), LINDSTROM states that complete linkage was found between the **Dd** (tallness vs. dwarfishness) and the **Pp** (smooth vs. pubescent skin) pairs of genes in the cross, **ddPP** $\times$ **DDpp**.

1) The haploid chromosome number in *Lycopersicum esculentum* is 12. (Vide TISCHLER, loc. cit.)

TABLE XII.—INHERITANCE IN THE TOMATO.

Contrasted characters	F ₁	F ₂	Authors
<i>Fruit Color</i>			(HALSTED (54, 546) CRAIG (72) HEDRICK & BOOTH (75) HURST (76) PRICE & DRINKARD (99) GILBERT (234) LINDSTROM (1188, 1286) FRIMMEL (1254) and others.
Red—yellow flesh	Red	3 red : 1 yellow	
Yellow—colorless skin	Yellow	3 yellow: 1 colorless	
The red endocarp color (R) is due to red needle-shaped crystals (lycopersicin) occurring within the cells of the mature fruit. The yellow color (r) is due to the yellow granular bodies. The yellow epicarp color (Y) is due to a distinct, yellow pigment suffused throughout the cell walls of the epidermis of the fruit, and is dominant to colorless (y). Hence we have four different combinations : RY Orange red (red flesh and yellow skin), Ry red (red flesh and colorless skin), rY dark yellow (yellow flesh and yellow skin), ry pale yellow (yellow flesh and colorless skin).			
<i>Fruit Shape</i>			(HEDRICK & BOOTH (75) PRICE & DRINKARD (99) GILBERT (234) FRIMMEL (1254) and others.
Spherical—pear-shaped	Spherical	3 spherical: 1 pear-shaped	
Roundish conical—roundish compressed	Conical	3 conical : 1 compressed	
CRANE (387) established the following scheme of genes : AB conical, Ab round, aB long, ab compressed round.			
<i>Fruit Size</i>			(GILBERT (244) MYERS (360, 1200) LINDSTROM (1188) and others.
Large—small	Large or intermediate	Continuous gradations	
<i>Fruit Surface</i>			(PRICE & DRINKARD (99) LINDSTROM (1286) and others.
Smooth—pubescent	Smooth	3 smooth: 1 pubescent	
WELLINGTON (977), from crosses between coarse types (Earliana and June Pink) and smooth types (Bonny Best and Chalk Jewel), concludes that the surface character depends upon numerous genes, and is transmitted as an intermediate character.			

Contrasted characters	F ₁	F ₂	Authors
<i>Leaf Color</i> Green—yellow	Green	3 green : 1 yellow	PRICE & DRINKARD (99)
<i>Leaf Margin</i> Serrate (normal)—entire ('potato')	Serrate	3 serrate : 1 entire	
<i>Leaf Type</i> Pimpinellifolium—esculentum	Pimpinellifolium type	3 pimp.: 1 esc.	
<i>Stature</i> Standard—dwarf	Standard	3 standard : 1 dwarf	CRAIG (72) GILBERT (234) HEDRICK & BOOTH (75) PRICE & DRINKARD (99) HOOD (408) JONES (497) LINDSTROM (1286) and others.
There is apparently a correlation between the habit of vine and leaf surface. Dwarf plants always have a more rugose foliage than standard plants.			
WELLINGTON (977) reports that decumbent habit of growth in Earliana and June Pink was dominant to the more vigorous and erect type found in Stone, Chalk Early Jewel, etc.			
<i>Inflorescence</i> Simple—complex type	Simple	3 simple: 1 complex	CRANE (387)
In the 'complex' type, the inflorescence is completely adnate throughout the axis, and does not break away from an internode, but does opposite to a node. Another feature of this type is that an inflorescence forms at the termination of two genetic spirals (six nodes). In the 'simple' type, however, there is only one genetic spiral between the inflorescences, and the latter are not adnate, but break away in the internode.			
<i>Loculation of Ovary</i> Bilocular—plurilocular	Bilocular	3 bilocular: 1 plurilocular	PRICE & DRINKARD (99) FRIMMEL (895) and others.
LINDSTROM (1286) mentions, however, that there are several genes concerned.			
<i>Sterility</i> Normal—contabescent	Normal	3 normal : 1 contabescent	CRANE (387)
<i>Mature Time</i> Early—late	Early (earlier than the parent)		WELLINGTON (977)
<i>Resistance to Disease</i> Resistant—susceptible to wilt-disease to bloossom-end-rot	Susceptible Resistant	Resistant (no segregation)	NORTON (97) STUCKEY (468) HARLAND (548)
" " " "	Slightly susceptible		

Lythrum Salicaria

Lythrum Salicaria is a trimorph-heterostyled plant. According to BARLOW (272, 982), crosses involving either mid or short style with long style always give offspring of the two parental types only, in about equal numbers, and those between mid and short style give offspring in the ratio of 1 long : 1 mid : 2 short or in some cases 1 long : 3 mid : 4 short. These results were genically interpreted by UBISCH (850, 1317) by assuming two genes, **A** for short style, and **B** for mid style ; thus :

AB	}		short-styled,
Ab			
aB		mid-styled,	
ab		long-styled.	

Usually mid style was assumed to have a genic constitution of **aaBb**, and long style **Aabb** (or sometimes **AaBb**). But, as BARLOW pointed out, there are some exceptional cases not in accordance with this scheme of genes. For example, the same short-styled plants which behaved as **AaBb** in crosses with mids (giving offspring in a ratio of 1 long : 3 mid : 4 short), gave in crosses with longs only longs and shorts in a 1 : 1 ratio, producing no mids, as would be naturally expected.

Malope trifida

RASMUSON (462) made crosses between white-flowered and red-flowered plants, and obtained red F_1 plants, giving in F_2 a monohybrid ratio of 3 : 1. Plants with red flowers bear also red anthers, pollen grains, internodes and pedicels.

Malva

KRISTOFFERSON (1047) made a species cross between *M. oxycloba* and *M. parviflora*. The leaves of the latter are circular-ovate with 5–7 rather small lobes ; the leaf margin is serrulated. The former has nearly the same leaf shape, but the lobes of the leaves are divided into lanceolate lobules with serrated margin. The lobes of sepals are ovate triangular. The results from crossing indicate that the segregation is a typical monohybrid one, giving a ratio of 3 *oxycloba* type : 1 *parviflora* type. Thus a single gene produces serrated leaves and pointed sepals, its absence resulting in serrulated leaves and round sepals.

KRISTOFFERSON gives also a brief account of F_1 hybrids between several other species of *Malva*. Among them a cross, *M. neglecta* $\times$ *M. oxyloba*, showed dominance of the larger flowers of the former and the serration of the leaves of the latter. The good frost resistance, characteristic of *oxyloba*, behaves as an incomplete dominant character.

Matthiola

Flower Color. TSCHERMAK (207, 268), from a cross of *M. incana* var. *rubra* (rose) by *M. glabra* var. *alba* (white), obtained pale purple in F_1 and a trihybrid segregation of 27 pale purple : 9 deep purple : 9 rose : 3 deep red : 16 white in F_2 . These results were also obtained by SAUNDERS (15, 47, 57, 200) to whom we owe the bulk of our knowledge on the inheritance of flower color in *Matthiola*. The extensive work of the latter author led to the following assumption of genes :

C } : basic genes for the production of anthocyanin, in the absence
R } of either or both of which the flower is uncolored.

B : a gene converting the blue-red class to the purple class.

P : a gene causing dilution in color.

X : a gene causing the difference between the pure and dull (or impure) color.

The color varieties may be represented thus :

CRBPX		pale purple,
CRBpX		deep purple,
CRBpx		plum,
CRbPX		rose,
CRbpX		deep red,
CRbpx		copper,
Cr(BPX)	}	white.
cR(BPX)		
cr(BPX)		

Cream is due to pigments in the plastids, and behaves as a simple recessive to white. The heterozygotes, **Ww**, are sulphur-white.

In a later publication (1208), SAUNDERS reports that the manifestation of sap color is dependent upon still further genes, **A** and **A₁**. White *incana* contains both **C** and **R**, but is nevertheless white-flowered, though the petals are sometimes tinged owing to lack of **A**. Such a white *incana*, when crossed with var. *alba*, gave purple F_1 . Some commercial sulphur-whites (**Cr**) proved to lack **A₁**. In F_2 of crosses of such a strain

with forms containing **R**, a proportion of **CR** plants was white-flowered. That **A₁** is not identical with **A**, was deduced from the fact that white *incana* × such a sulphur-white gives purple **F₁**.

Hoariness. SAUNDERS (15, 47, 57, 200, 262, 465, 739, 1208) found that hoariness is dominant to glabrousness. The difference of these two types depends upon two pairs of genes, the one pair being essential for the production of sap color, namely **C** and **R**, the other for hoariness, **H** and **K**, the latter pair being, however, non-effective, unless combined with the former. The half-hoary race in which the lower surfaces of the leaves are hoary, while the upper surfaces are glabrous or nearly so, was found to lack **H** but contain **K** and an additional gene **H₁**. The genes **H**, **H₁** and **h** appear to form a system of triple allelomorphism. When the individual has the constitution **H₁H₁KK**, **H₁H₁Kk** or **H₁h₁KK**, the result is half-hoary, while the constitution **H₁h₁Kk** results in the less degree of hoariness known as quarter-hoary.

Doubleness of Flowers. The double flowers in *Matthiola* are of the extreme type of doubleness; namely, they produce neither pollen nor ovules.

SAUNDERS (199, 200) found a peculiar mode of inheritance of this character. The essential features may be given as follows:

1) In most varieties of stocks, two kinds of singles may be genotypically distinguished, (a) the double-throwing type, giving a mixture of singles and doubles in an approximate ratio of 15:17, (b) the non double-throwing type, breeding true to singleness.

2) Reciprocal crosses between these two types yield different results: (α) in the cross, type (b) ♀ × type (a) ♂, all the **F₁** plants give a mixture of singles and doubles in **F₂**, (β) in the cross, type (a) ♀ × type (b) ♂, only a little more than half the **F₁** plants give a mixture of singles and doubles, the remainder breeding true to singleness.

The proportion of doubles to singles in the mixed progenies from either kind of crossing was found in most cases to be 1:3. These curious results were explained on the following assumption:

1) Singleness results from the presence of two genes: **X** and **Y**, while doubleness results from the absence of either or both.

2) In the type (b), **X** and **Y** are absolutely linked together (**XY**).

3) In the type (a), these two genes are carried only by the ovules and exhibit partial linkage, but the pollen is unable to possess either **X** or **Y** or both.

Thus the gametic series in the two types of singles may be given as:

TYPE (b)		TYPE (a)	
Ovules	Pollen	Ovules	Pollen
$\overline{XY}$	$\overline{XY}$	15 XY	xy
		1 Xy	
		1 xY	
		15 xy	

Later GOLDSCHMIDT (285) explained the inheritance of doubleness by sex linkage and lethal action of a gene for femaleness in pollen formation. FROST (393, 623) and PRELL (1203) presented similar lethal gene schemes. As to these discussions, refer to the original papers.

Other Characters. CORRENS (3), in crosses of *incana* with *glabra*, made some observations on the inheritance of aleurone color (blue dominant to yellow), seed-coat color (brown to light yellow), stature (tall to dwarf) and other characters. The blue aleurone was found to be always associated with colored flowers, the yellow aleurone with white or cream flowers.

SAUNDERS (47) mentions that the absence of glands on leaves is dominant to its presence. In another paper (200), the same investigator reports branched habit to be dominant to unbranched.

*Linkage Relations.*¹⁾ According to SAUNDERS (especially 199, 200), X and Y are partially linked in all the ever-sporting (i.e. double-throwing) strains, as already shown under 'Doubleness of Flowers.' In the same paper, she reports further that this kind of inter-relationship exists also between the gene producing white plastid color (W) and the genes for singleness ($\overline{XY}$) and also between the gene W and the gene producing pale sap color (P). Further it was found that the peculiar sulphur-white race, $XxYyWw$, when selfed, gives a mixture of white singles and cream doubles. In this case, the gene W appears to be linked with one of the XY genes. Later (1208), she obtained results indicating that one of the two genes for sap color (taken to be R) is completely linked with one of the two genes for hoariness (taken to be H). This inter-relationship $\overline{RH}$, however, was not universal, but was found often to break up in some progenies of certain crosses.

Meconopsis cambrica

SAUNDERS (511) reports that in the double-flowered type this

1) The haploid chromosome number in *Matthiola incana* is 7. (Vide TISCHLER, *loc. cit.*)

characteristic varies considerably, even in one and the same individual. In the most extreme type of doubling all of the stamens are present in the forms of petals. Doubleness was found to differ by a single gene from singleness, the former being dominant.

Medicago

Flower Color. WITTE (857) made a cross between *M. sativa* and *M. falcata*, the former having bluish violet flowers, while the latter bear bright yellow flowers. The F_1 plants showed an intermediate color in the flower, being dirty yellow (or greenish yellow) with more or less distinct violet-green veins. In F_2 a complicated segregation was obtained, including various colors such as bright yellow, violet-brown, bluish violet and white.

Habit of Growth. SOUTHWORTH (370) made some observation on the cross between *M. sativa* (♀) and *M. lupulina* (♂), the former having an erect habit of growth, while the latter is prostrate. The F_1 plants considerably differed from either of the parental forms. The F_2 progeny raised from one of these F_1 plants consisted of several different types, prostrate, decumbent, semi-erect and erect. Grouping these into erect and non-erect classes, a tendency to the monogenic segregation was obtained, the non-erect habit being dominant.

WALDRON (856) and WITTE (857), in crosses between *M. sativa* and *M. falcata*, obtained the F_1 plants showing an intermediate condition. In F_2 a complex segregation occurred, most plants being open as in F_1 , but some having erect stems as with *sativa* and the others decumbent stems as with *falcata*.

Other Characters. SOUTHWORTH (370), in F_2 of the cross of *M. sativa* × *M. lupulina*, observed a wide range of variation for height of plant. Treating the plants with height of 5.5 inches or less as dwarfs, and those with height taller than 5.5 inches as tall, he obtained one main-gene difference, the tall habit being dominant.

M. sativa has spiral pods, while those of *falcata* are sickle-shaped. According to WITTE (857), the F_1 plants showed an intermediate pod-shape and in F_2 a wide range of variation occurred.

BRYAN & PRESSLEY (763) studied the inheritance of heading date in *M. sativa*. The mean heading date of pure Sonora plants was April 7 (in 1918); of pure Turkey plants, May 1; and of the F_1 plants of the Sonora-Turkey cross, April 18. Of 4,892 F_2 plants, only 66 headed as early as the latest head on Sonora, while 1,435 plants headed as late as the earliest head of Turkey.

Mercurialis annua

CORRENS (684) describes two types of chlorophyll deficiencies in this plant: xantha and versicolor. In the former, the seedlings are yellow and eventually perish. Duplicate genes are concerned in the inheritance, giving both 15:1 and 3:1 ratios of green to yellow seedlings. Three genes were assumed: **Z** for the xantha type, **N₁** and **N₂** for the normal type. Thus: *

$$\begin{array}{l} \text{ZN}_1\text{N}_2 \\ \text{ZN}_1\text{n}_2 \\ \text{Zn}_1\text{N}_2 \end{array} \left. \vphantom{\begin{array}{l} \text{ZN}_1\text{N}_2 \\ \text{ZN}_1\text{n}_2 \\ \text{Zn}_1\text{N}_2 \end{array}} \right\} \dots\dots\dots \text{typica,}$$

$$\text{Zn}_1\text{n}_2 \dots\dots\dots \text{xantha.}$$

The versicolor race appears yellow at first, but it gradually becomes green and the plant survives. This type is a simple recessive to the normal green.

Mimulus

Extensive work has been done on the inheritance of several characters in *Mimulus* by BROŽEK (762, 990, 991, 992, 993).

Spots on the Petals. *M. quinquevulnerus rubinus* has color spots on the entire petal-surface, while in *M. q. speciosus* the spots are limited to only half the surface. The 'rubinus' type proved to behave as a simple dominant over the 'speciosus' type.

M. tigrinus variegatus has large 'ragged' spots on the petals, while *M. t. luteus* has no such spots. The F_1 plants showed an intermediate state. F_2 has not yet been investigated. The cross between *rubinus* and *luteus* gave less 'ragged' spots than those of *variegatus*.

Floral Construction. CORRENS (50) found a plant with abnormal, petaloid calyx of *M. tigrinus*. This type behaved as an imperfectly dominant character against the normal.

BROŽEK made crosses between the double-flowered lines (paracorolla) of the *M. tigrinoides* race and the single-flowered lines of the other race of *rubinus*. The paracorolla consists of a few, narrow excrescences from the inner surface of the corollar tube, covering the filaments completely and reaching partly outside the flower. The F_1 plants were normal, and always gave in F_2 among 16 plants 1 plant with flowers more or less double. According to his interpretation, there are two genes **A₁** and **A₂**, each of which entirely or partly inhibits the action of gene **P**

concerned in the paracorolla formation; thus the *tigrinoides* race has the genic constitution, $a_1a_2a_2PP$, while the *rubinus* race has $A_1A_1A_2A_2pp$. The F_1 plants are of $A_1a_1A_2a_2Pp$, which can not produce a paracorolla and will give in F_2 the ratio of 15 single : 1 double.

BROŽEK also made some observations on the inheritance of the presence or absence of the peloric flower. *M. t. variegatus* has the peloric, terminal flower, while *M. q. rubinus* lacks it, the side flowers being zygomorphic. In F_1 , the presence of the peloric flower is completely dominant to its absence. F_2 has not yet been raised.

Variegation. Variegated calyx—green with white striping—was observed in *M. rubinus*, *M. speciosus* and others. This character proved to be transmitted exclusively through the mother plant.

Mirabilis Jalapa

Flower Color. The inheritance of color in *Mirabilis Jalapa* is characterized by the existence of a number of heterozygous forms. Thus CORRENS (17, 51, 129) obtained rose by crossing white with yellow, and BAUR (88) found similar heterozygous forms in F_1 . Later MARRYAT (118), working at a number of color varieties, completely analyzed the genes for flower color in *Mirabilis*. The results of crossing are briefly tabulated in TABLE XIII. For interpretation of the results, she assumed the following two genes: **C** for yellow sap color and **M** for red

TABLE XIII.—A SUMMARY OF RESULTS OBTAINED BY MARRYAT (118), CONCERNING THE INHERITANCE OF FLOWER COLOR IN *Mirabilis*.

Contrasted colors	F_1	F_2
White—yellow	Pale yellow	1 white : 2 pale yellow : 1 yellow
White—crimson	Deep magenta	1 white : 2 deep magenta : 1 crimson
Yellow—crimson	Orange-red	1 yellow : 2 orange-red : 1 crimson
White—crimson	Magenta-rose	White, pale yellow, yellow, magenta-rose, crimson, orange-red, magenta in an approximate ratio 4 : 2 : 1 : 4 : 1 : 2 : 2.
White—yellow	Magenta-rose	Magenta-rose, magenta, orange-red, pale yellow, crimson, yellow white in an approximate ratio 4 : 2 : 2 : 2 : 1 : 1 : 4.
White—white	White	White

sap color. **M** has no effect without **C**. The color varieties may be represented in a tabular form, thus :

CCMM		crimson,
CcMM		magenta,
CcMm		magenta-rose,
CCMm		orange red,
CCmm		yellow,
Ccmm		pale yellow,
ccMM	}	white.
ccMm		
ccmm		

It was also found that certain two whites crossed together gave colored forms in F_1 . This fact suggests that for production of color two genes are involved.

Besides these full colors, *M. Jalapa* presents a remarkable series of striped varieties. They proved to be always heterozygous, giving self-colored and striped individuals.

Chlorophyll Deficiencies. CORRENS (28, 110, 129, 534) describes a number of chlorophyll deficiencies. The xantha type has only about 5 per cent as much chlorophyll as the normal (typica) plant and is non-viable. But it survives when grafted on green plants and may set seeds. Chlorina has about 30 per cent and semi-chlorina about 60–70 per cent of normal chlorophyll. These two types show a proportional reduction of both chlorophyll and the carotinoid pigments. In xantha, the content of yellow pigments is normal. Variegata has a ground color of chlorina with full green flecks superposed. There are various grades of variegata; the palest type is hardly distinguishable from the chlorina. Albomaculata has leaves with white and green streaks and flecks. Various crosses were made between these types. Variegata usually behaves as a simple recessive to the normal green. Some crosses, typica $\times$ variegata, gave in F_2 typica, variegata and chlorina in a 12:3:1 ratio. Sometimes the variegated plants bear a branch entirely green. The self-fertilized offspring of the green branches consists of greens and variegateds in a ratio of 3:1, indicating that the green branches are heterozygous, while the variegated branches give progenies consisting almost entirely of variegatas with a very small percentage of greens. Similar somatic diversity was observed in the albomaculata type, which often bears branches entirely white or entirely green. The green branches, when selfed, give only green plants; the white branches give pure white seedlings which are nonviable; while the albomaculata-branches give three types: pure white, albomaculata and entire green. It was found from crosses with typica and chlorina that albomaculata

is genetically the same as the typica and show absolutely cytoplasmic inheritance.

Crosses with typica, xantha and chlorina gave results which led him to the following scheme of genes :

NCZ typica,
nCZ chlorina,
NcZ } xantha.
ncZ }

In the formulae, Z is the gene for yellow pigments, C for chlorina and N for typica which is active only in the presence of C. Typica-chlorina heterozygotes (NnCCZZ) have 90 per cent of normal chlorophyll, while chlorina-xantha heterozygotes (nnCcZZ) and typica-heterozygotes which throw chlorina (NNCcZZ) are indistinguishable from the respective homozygotes, indicating that Cc has the same effect as CC. Curiously, however, NnCcZZ plants were found somewhat darker than NnCCZZ plants.

Physiological Characters. CORRENS (224, 386) found in his cultures plants which are easily distinguished from the normal by light brown spots developing on the upper surface of the leaves. These plants are weaker in growth than the normal, and their green color presents a dirty appearance. An anatomical study showed that what is affected first is the palisade tissue, and then the epidermal cells are altered and destroyed, forming a brown spot. Such plants were called by the name

TABLE XIV.—INHERITANCE OF SOME CHARACTERS IN *Mirabilis*.
After CORRENS (17).

Contrasted characters	F ₁	F ₂
<i>Habit of Growth</i>		
Tall—half-dwarf	Tall	
Tall—dwarf	Tall	3 tall: 1 dwarf (CORRENS, 110)
Half-dwarf—dwarf	Half-dwarf	3 half-dwarf : 1 dwarf
<i>Length of Corolla</i>		
Long (<i>M. J. longiflora</i> , 137 mm.) —short (<i>M. J.</i> , 42.5 mm.)	Intermediate (67 mm.)	
<i>Size of Pollen Grains</i>		
Large (<i>M. J. longiflora</i> , 243μ)— small (<i>M. J.</i> , 189μ)	Large (237μ)	

'Sordida' and the disease 'Sordago'. It was found that 'Sordida' differ from the normal by a single gene, the former being recessive.

In another paper (281), the same author reports that cold-hardiness is dominant to non-hardiness (*M. J. f. delicata*), giving in F_2 a monogenic ratio.

Other Characters. CORRENS (17) describes the F_1 plants of several crosses. A summary of his results is given above in a tabular form (TABLE XIV).

Mosla

NAGAI (941, 1059) has published two papers on this genus.

Flower Color. *M. Orthodon* has purple flowers, while *M. leucantha* bears white flowers. The difference of flower color was found to be monogenic, giving in F_2 a ratio of 1 purple : 2 tinged : 1 white. In the white-flowered plants, the leaves are almost free from the purple pigment and also the stem is very slightly colored. At the end of the growing season, the leaf does not turn purple as in the plants with colored flowers.

Habit of Growth. *M. Orthodon* is pyramidal in general appearance and has horizontal basal branches, while *M. leucantha* is bushy and has convergent branches. The data suggest a monogenic difference, giving in F_2 an approximate ratio of 1 : 2 : 1, though the exact discrimination was very difficult.

A cross between *M. Orthodon* and *M. Hadai* gave in F_2 three types of the growth habit: (1) normals, (2) half-dwarfs and (3) dwarfs. In the last two, the branches grow very densely. Dwarfishness is characterized by shortening of the length (not by the reduction of the number) of the internodes. Dwarfs are dihybrid recessive to normals, indicating a ratio of 15 (normals + half-dwarfs) : 1 (dwarf) in F_2 . Among dwarfs, very narrow and crisped leaf appeared, conforming to the ratio of a monohybrid recessive.

Chemical Character. *M. Orthodon* produces thymol dissolved in the volatile oil contained in the leaf, whereas *M. Hadai* produces no thymol, but its isomer, carvacrol, which is not crystallizable and is of no practical value. This chemical difference was shown to be governed by several genes.

Nicandra physaloides

DAHLGREN (1123) reports that the presence of spots at the base of the petals (*typica*) is dominant to their absence (f. *immaculata*).

Nicotiana

COLOR INHERITANCE

Flower. HOWARD (295) made a cross of *N. Tabacum* between pink and very pale pink fading into white, and obtained in F_2 72 pinks of various shades and 45 whites, but some of the palest pinks were not distinguishable from the white. It is stated that "the difference in the colour of the corolla in this case was probably due to two factors."

ALLARD (597) states that *N. Tabacum* exhibits three distinct flower colors—carmine, pink and white. The difference between carmine and pink is monogenic, carmine being dominant. In crosses of carmine or pink with white, white behaved as a recessive, reappearing in F_2 . Some of the F_2 plants classified as white revealed a tinge of color. Crosses of extracted whites with pink gave 32 carmine and 62 pink, showing that extracted whites sometimes carried a gene for carmine.

CLAUSEN & GOODSPEED (767) and SETCHELL, GOODSPEED & CLAUSEN (955) demonstrated that the red flower color of *macrophylla* is recessive to the light pink of *angustifolia*, and the same relations are exhibited by the red of *calycina* as contrasted with the light pink of *virginica*. In both cases, F_1 was pink, giving in F_2 a 3 (pink): 1 (red) ratio. When *macrophylla* was crossed with the white-flowered variety *alba*, F_1 was pink, F_2 conformed to the ratio 9 pink: 3 red: 4 white. At first sight these results seem to be contradictory to those of ALLARD. But ALLARD'S 'carmine' is identical with dark red in these papers. Dark red of *macrophylla purpurea* crossed with white gave dark red in F_1 , instead of pink as was obtained from red $\times$ white, indicating that dark red differs from pink in having a dominant gene. Thus the scheme of genes may be represented as:

WRP dark red (carmine),
WRp light pink,
Wrp red,
wRp white.

This scheme of genes has been confirmed by KELANEY (1278) and CHRISTOW (1241). ALLARD and KELANEY demonstrated also that the white flower color (with a yellowish tinge) of *N. sylvestris* is completely recessive to the colored type of *N. Tabacum*.

The green color of *N. Langsdorffii* is due to chlorophyll grains in the tissue of the corolla. LOCK (117) found the green color of *Langsdorffii* to

be a simple dominant to the absence of this color. But the shade of green shown by the heterozygote was distinctly paler than that of the homozygote. A similar result was obtained by EAST (437).

SACHS-SKALIŃSKA (836) made crosses between *N. Langsdorffii* and *N. Sanderæ*. Four color genes were determined in *N. Langsdorffii*:

Z₁: produces a very dark green color.

Z₂: produces a very clear cream color.

E: distributes chlorophyll grains on the external side of the corolla.

W: acting together with **E**, distributes chlorophyll grains on the internal side of the corolla.

The genes **Z₁** and **Z₂** were found to be linked according to a gametic ratio of 3:1 or 5:1.

It was found also that the flower color of *N. Sanderæ* and its distribution are governed by the following several genes:

F: basic gene for the production of anthocyanin in the cell sap; by itself produces a violet color.

C: acting together with **F**, produces a red color in the sap; by itself has no effect, thus **FC**=red, **Fc**=violet, **fc** or **fc**=white.

I₁ and **I₂**: genes for intensification of colors, which when acting together have a cumulative effect, the depth of color depending upon the number of dominant genes present in the zygote.

N, **T**, **P** and **R**: genes responsible for the distribution of anthocyanin.

N: determines the appearance of a red pigment on the external face of the corolla with traces of red on the outer surface of the tube of the corolla.

T: acting together with **N**, determines a very slight pigmentation on the external surface of the corollal tube.

P: acting together with **F**, distributes anthocyanin in the epidermis of the inner side of the corolla.

R: acting together with **F**, distributes anthocyanin in the parenchyma of the corolla.

Interrelations of **F**, **C**, **I₁**, **I₂**, **P** and **R** may be given as:

FI₁I₂PR	}	dark violet (with c) or dark red (with C) internal side of the corolla,
FI₁I₂Pr		
FI₁I₂pR		
FI₁i₂PR or Fi₁I₂PR	} . .	dark lilac (with c) or rose (with C) internal side of the corolla,
FI₁i₂Pr or Fi₁I₂Pr		
FI₁i₂pR or Fi₁I₂pR		

$\left. \begin{array}{l} \text{Fi}_1\text{i}_2\text{PR} \\ \text{Fi}_1\text{i}_2\text{pR} \\ \text{Fi}_1\text{i}_2\text{Pr} \end{array} \right\} \text{lilac (with c) or pale rose (with C) internal side of the corolla.}$

Filament. KELANEY (1278) working with *N. Tabacum* found that carmine (corolla color) with pink filaments crossed with pink with green filaments gave F_1 plants which bore carmine corolla with pink filaments, and in F_2 the segregation occurred in a ratio of 9 carmine with pink filaments : 3 carmine with green filaments : 4 pink with green filaments. From these results, a gene, **G**, was assumed for pink filament color which manifests itself only in the presence of the gene for the carmine corolla color, **P**.

Pollen. LOCK (117) reports that in *N. Langsdorffii* blueness of the pollen appears to be dominant to the absence of blue (white or grayish pollen). The heterozygote, however, is invariably of a distinctly paler blue color than the homozygote. EAST (437), in crosses between *N. Langsdorffii* (pollen blue) and *N. alata* (pollen yellow), showed that the difference between the blue and the yellow is monogenic, the blue color being dominant.

OTHER FLOWER CHARACTERS

Abnormal Construction of Flowers. KLEBS (452) found double-like flowered plants (his lacerata-form) in a field of *N. Tabacum* var. *virginica*. This, when selfed, gave a progeny of 1 typica (normal) : 2 lacerata : 1 apetala. The lacerata-form is heterozygous. The apetala-form in which the corolla is entirely lacking seemed to be a simple recessive. The proportion of apetalous plants, however, was always below expectation. He ascribed this deficiency to their comparatively low viability.

SETCHELL, GOODSPEED & CLAUSEN (955) dealt with the behavior of another abnormal form, calycina. This is a hose-in-hose type with corolla usually split on one side, and behaves as a simple recessive to the normal form of *virginica*.¹⁾

Recently KELANEY (1278) reported that in the typica, so-called by KLEBS, the corolla is normal in form, but the calyx has a tendency to be petaloid at the tips and the type has a genic constitution different from that of other normal forms. The typica of KLEBS is now called KLEBS-normal. Normal and KLEBS-normal gave only normal plants in

1) WHITE (478), however, obtained in F_1 an intermediate form, and in F_2 a ratio of 1 calycine : 2 intermediate : 1 normal. He assumed a dominant gene **B** for calycanthemy.

F₁ and F₂, and on backcrossing F₁ normal to apetalous, the result was 1 normal: 1 lacerate. From the study of several other crosses and backcrosses, he concluded that these flower forms are governed by the following genes:

C-c-c^a: a series of triple allelomorphs for flower shape; **C**=normal, **c**=calycine, and **c^a** together with the genes **Ap** and **ap** gives the KLEBS-types. Dominance is in the order indicated: **C>c>c^a**.

Ap-ap: normal (**Ap**) vs. apetalous (**ap**) form.

Hence the genic scheme is thus:

CAp**** normal,
cAp**** or **cap** calycine,
c^aAp**** KLEBS-normal (**ApAp**) or lacerate (**Apap**).
c^aap**** apetalous.

WHITE (377) dealt with a pistilloid race which originated from a single anomalous mutant found among the segregates of F₂ from *N. Langsdorffii* × *N. alata*. The plants were characterized by the presence of small pistils adherent to the anthers. The degree of pistillody was very variable. Crosses with the normal gave in one case a 3:1 ratio in F₂ the pistillody being recessive. In two hybrids, it proved completely recessive, while in another hybrid, it was completely dominant. He also made some experiments with a catacorolla race which had a similar origin. This race, when crossed with normal races, gave the F₁ progeny which were either intermediate or absolutely normal. These changes in dominance were ascribed to the modifying influence of other genetic or external factors.

Length of the Pistil and Filaments. HOWARD (1153) working with *N. rustica* made crosses between plants with anthers below stigma and those with anthers above the stigma level. The F₁ resulted in the dominance of the former and gave in F₂ segregation in a monogenic ratio. In another case—anthers below × anthers above—, however, the F₁ anthers were slightly above the stigma and a series was obtained in F₂ with every gradation between the two parental types.

Form of the Inflorescence. According to HOWARD (1153), open inflorescence is dominant to the compact type in *N. rustica*.

Size of Corolla. The inheritance of spread, length and diameter of corolla has been studied by GOODSPEED (235, 286, 397) in *N. acuminata*, by EAST (282, 436) in *N. Langsdorffii* × *N. alata*, by HOWARD (295) and

SETCHELL *et al* (955) in *N. Tabacum*, by HOWARD (1153) in *N. rustica*. In general the F_1 plants are intermediate between the parents and in F_2 a series with a range of variation equal to the combined ranges of the parents is obtained. Multiple genes are responsible for the character.

Recently CHRISTOW (1241) dealing with *N. Tabacum* found three genes concerned in the size of corolla; **A** produces large corolla, **a** small, **B** and **C** separately further depressing the size, and with **A** giving intermediate.

OTHER MORPHOLOGICAL CHARACTERS

Anomalous Types. WHITE (322, 377, 478) observed a teratological form which arose as a spontaneous variation and had the fasciated stem, accompanied by repetition in the number of organs, such as leaves, sepals, petals, stamens and ovary locules. This abnormality proved to be a simple Mendelian dominant to the normal. The F_1 plants were intermediate in character, and F_2 gave abnormal (**AA**), heterozygous (**Aa**) and normal (**aa**) segregates in the ratio of 1:2:1 or 3 abnormal to 1 normal.

HONING (494, 1025) found a plant of an abnormal type in a field of Deli tobacco. The plant was characterized by a zigzag form of stem, and small, long-stalked leaves with small appendages on the under side of the leaves and on the corolla and with so-called 'drip tips' on the leaves. This plant, when selfed, gave normal plants, plants with the mother type and sterile-dwarfs (designated as *N. deformis*) 30–40 cm. in height, having long-stalked, irregularly shaped leaves with drip tips and many appendages on the under side. These three segregates appeared in a ratio of 1:2:1. The dwarf plants did not flower in Sumatra, but came to flowering in Holland. They, when selfed, remained constant. Crosses with the original mutant gave these two types in a 1:1 ratio. These results indicate that the original mutant is a monogenic heterozygote, and the sterile-dwarf plant a pure recessive.

The sudden appearance of giant or mammoth plants with abnormally high leaf number in *N. Tabacum* has been recorded by several investigators. They have an indeterminate growth habit and do not flower under ordinary field conditions, but when transferred to the greenhouse at the end of the growing season they flower. In crosses with normal varieties, they behave as a recessive to the normal habit of growth (ALLARD, 598; JONES, 799; TUKADA, OKADA & TERAU, 1093). JONES obtained in F_2 the segregation of 82 normals to 1 giant in one case,

6 normals to 1 giant in another case. On the other hand, ALLARD and TUKADA *et al* found a monogenic ratio of 3 normals to 1 giant, though there were considerable deficiencies of the recessives.

Chlorophyll Characters. A light, yellowish green type of *N. rustica* with white stems and midribs and yellowish green leaves has been designated as 'aurea'. LODEWIJKS (185) found that aurea-type behaves as a heterozygote, segregating when selfed into green and aurea-types. Crosses between green and aurea gave both types in about equal numbers. On the other hand, ALLARD (599) reported that the aurea type of *N. rustica* is monogenically different from the normal green type, the aurea type being recessive.

As regards the leaf color in *N. Tabacum*, KAJANUS (1163) found that the green leaf of 'Brazil' is dominant to the yellow of 'White Burley'. In F_2 , he obtained 5037 green and 229 yellow plants, but since their classification was often difficult, he believes that this represents a 15:1 ratio.

Leaf Types. LODEWIJKS (185), HAYES (237) and HOWARD (295) studied the inheritance of several leaf forms in *N. Tabacum*. The intermediacy of F_1 and the complex variability of F_2 were emphasized by them.

As respects the inheritance of length of the decurrent portion of the lamina, HOWARD (295) found that this character is due to the existence of several genes. In one of the crosses where both parents have equally decurrent leaves, she obtained some non-decurrent types in F_3 . The numbers obtained pointed to a 63:1 ratio. As to the leaf base, she obtained by the hybridization of two sessile forms some petiolate types which bred true, in two cases a simple segregation in a 1 (petiolate): 2 (intermediate): 1 (sessile) ratio being observed.

SETCHELL, GOODSPEED & CLAUSEN (955) crossed *angustifolia* with *macrophylla*, the former having petioled leaves, the latter broad leaves which are sessile and taper gradually to broad, partially-clasping basal lobes. The F_1 plants were short-petioled, and the F_2 showed a complex series of forms ranging from extremely long-petioled to very broad types. After testing different segregates, they found that the following pairs of characters are monogenically different from each other: petioled—broad, petioled—constricted, short-petioled—broad and broad—constricted. In the constricted type, the leaves are sharply constricted at the base. From these results three gene pairs were assumed: **Ss**, petioled vs. broad; **Ll**, long-petioled vs. short-petioled; **Aa**, broad vs. constricted.

Later KELANEY (1278) obtained results in general agreement with

those of SETCHELL *et al.* He was able to recognize, however, a genetic distinction between broad and lanceolate types. Lanceolate leaves are also sessile and taper gradually toward both base and apex. As respects petiole length, he observed complex segregations, but no attempt was made to analyze them. On the basis of these facts he adopted the following genic scheme:

SA lanceolate,
 Sa petioled,
 sA broad,
 sa constricted.

The genic constitution **SsAa** gives the short-petioled condition of F_1 , which is different from the 'true breeding' short-petioled type.

Venation of the Leaf. HOWARD (295) states the lateral vein angle of the leaves (i.e. the angle formed by the midrib and the lateral vein) of *N. Tabacum* to be one of the most constant characters of the plant and largely independent of the shape and width of the leaf. Crosses between plants differing in the angle gave an intermediate condition in F_1 , and F_2 covered the combined range of the parents. In later generations, the parental forms were re-isolated and also constant forms with intermediate vein angles. Several genes are responsible for this character.

Surface and Margin of the Leaf. HOWARD (295) made a cross with *N. Tabacum*, where one of the parents has a very undulate surface of the leaf, while in the other the edge is frilled and the surface is flat, except at the extreme base. Taking the leaf surface only, it was found that F_1 was intermediate between the parents, and in F_2 a wide range of variation occurred. Grouping these plants into the undulate (including a few plants slightly more undulate than the parent) and the remaining types, the ratio approached to 1:15 indicating the existence of two genes for undulation. There was also evidence suggesting still another modifying gene. As regards the undulation of the margin, this appeared to be inherited independently of the surface undulations. In F_2 , plants with frilled margins and those with flat margins occurred in a 3:1 ratio. In a later paper (1153), she found also a similar monogenic difference in *N. rustica*.

Height of Plant. Observations on the inheritance of height of plant (*Tabacum*) have been made by several investigators:—JENSEN (77), LODEWIJKS (185), HAYES (237), HOWARD (295), EAST & HAYES (338), SETCHELL *et al.* (955) and others. In general multiple genes well

explain the results obtained. According to HOWARD, however, there exists a single gene which has a relatively great effect. Analogous results were also obtained in *N. rustica* by the same author (1153).

DAVID (1246) also observed clear segregation as regards the plant height in *N. Tabacum*. By grouping the F_2 plants according to the mean height of the parents, he obtained in some crosses the F_2 showing segregation into tall and dwarf in a 3 : 1 ratio, and some following 63 : 1, and others 15 : 1 ratios, respectively. When F_2 plants were grouped according to the modal heights of the plants, segregation generally followed the 3 : 1 ratio.

Number and Size of Leaves. That these characters are also typically Mendelian in inheritance as well as other quantitative characters has been elucidated by several authors:—HAYES (237), HAYES, EAST & BEINHART (289), HOWARD (295), EAST & HAYES (338) and others. As an example, the cross between Sumatra and Havana made by EAST & HAYES may be given. The Havana variety shows an average leaf number 19.8 per plant, while the Sumatra variety 26.5. The F_1 generation is intermediate in leaf number, producing an average of 23.3 leaves per plant. The F_2 plants show nearly the whole range of the variations. Some plants could not be distinguished from the pure Sumatra, others resembled Havana. Selected F_2 plants gave F_3 lines which differed in the average number of leaves. By continued selection, they were able to produce strains breeding approximately true to 30 leaves. These results are explainable by various combinations of genes.

Inclination of Leaves on the Stem. As regards the inclination of the leaves in *N. Tabacum*, HOWARD (295) made a cross between a form with drooping leaves and one with upright leaves. In general no definite conclusion could be given, but in one case clear segregation was obtained with the formation of intermediates.

Distribution of Leaves on the Stem. HOWARD (295) made also some observations on the arrangement of the leaves. With respect to this character, the plants could be divided into three groups: (1) rosette type, in which all the leaves are borne at the base of the plant, (2) ladder type, in which the leaves are borne at equal intervals along the stem, (3) intermediate type, in which the majority of the leaves are concentrated at the base, the rest along the stem. Crosses between rosette and ladder types were found to produce the intermediate type. The F_3 included, in addition to the parental forms, two different intermediate forms, one with a few leaves at the base, otherwise resembling the ladder type, and the other with a great concentration of leaves at the base.

PHYSIOLOGICAL CHARACTERS

Flowering Time. HOWARD (295) working with early and late flowering varieties of *N. Tabacum* found that F_1 is intermediate as regards this character, and in F_2 a complex segregation occurs, showing a wide range of variation. Similar results were also obtained in *N. rustica* by the same author (1153).

Resistance to Disease. JOHNSON (798) has studied the resistance in a cross, White Burley $\times$ Little Dutch, the former being susceptible and the latter resistant to *Thielavia basicola*. The F_1 plants were intermediate in resistance, and in F_2 no susceptible plants were found.

Self-sterility. Studies of self-sterility in tobacco, especially in self-sterile species, *N. Forgetiana* and *N. alata*, have been extensively made by EAST & PARK (486, 540), EAST (390, 391, 539, 617, 618, 619, 1001), ANDERSON (1103), and EAST & MANGELSDORF (1249). According to EAST & PARK, the self-sterile condition of *N. Forgetiana* and *N. alata* is recessive to the self-fertile *Langsdorffii*. In F_2 a ratio of approximately 4 self-fertile to 1 self-sterile plant was obtained. To account for these results, EAST assumed two genes, **F** for fertility and **D** for pseudo-fertility. The gene **D** produces in the absence of **F** some fertility under certain conditions, thus tending to lower the number of self-sterile segregates.

EAST & MANGELSDORF found that the offspring of a cross between two self-sterile plants (*Forgetiana* and *alata*) consists of three sterile classes, all inter-fertile, but intra-sterile. It was further found that when members of two different classes were crossed, the offspring consisted of two of the three classes in equal numbers, the class of the female parent being always excluded in the progeny. Thus for example Class X $\times$ Class Y or Z gave Class Y and Z in equal numbers, Class X used as the female parent being absent in the progeny. To explain these behaviors they assumed three allelogenes for sterility, S_1 , S_2 and S_3 . The three classes were represented in the following genic terms:

Class X = S_1S_3 ,

Class Y = S_1S_2 ,

Class Z = S_2S_3 .

A plant gives stimulus only to pollen carrying genes other than its own. Thus Class X can be fertilized only by the S_2 pollen and the resulting progeny is thus composed of S_1S_2 (Class Y) and S_2S_3 (Class Z) in equal numbers. The results of selfing—which was carried out by pollinating in the young bud—were as follows:

Class X gave S_1S_1 and S_1S_3 .

Class Y gave S_1S_1 , S_1S_2 and S_2S_3 .

Class Z gave S_2S_2 and S_2S_3 .

Members of Class S_1S_1 are fertile with S_2 and S_3 pollens, and those of Class S_2S_2 with S_1 and S_3 pollens. The failure of the expected Class S_3S_3 to appear in the selfed progenies of Class X and Z was explained by the assumption that S_3 is a lethal in the homozygous condition.

Nymphaea

[ANONYMOUS, 865]. Some observations were made on the inheritance of flower color in several species crosses.

Odontoglossum

HURST (116). The blotched character in the flower behaves as a dominant over the plain character, and yellow flower color over white.

Oenothera

Peculiar modes of inheritance have been found in the genus *Oenothera*, in the study of which considerable attention has been given to the results of hybridization of a large number of different species and varieties. These results are difficult to describe briefly in this monograph. As to the analysis of genes, we would refer to the work of LEHMANN (930) and that of RENNER (1298).

Some remarks, however, may be added regarding the linkage phenomena in *Oenothera*¹⁾, for they appear to play an important rôle in the solution of the complex inheritance of this genus. On this subject, SHULL (1077) states: "With the exception of one character (the short style of *brevistylis*) all of the characteristics thus far investigated, by which the numerous *Oenothera* species are differentiated, are determined by factors located in a single pair of chromosomes, which I have designated 'chromosome I.'" From the results obtained (1077, 1078), he identified the following genes as belonging to this first linkage group:

N—n: tall—*nanella* stature.

R^h: red hypanthium of *rubricalyx*.
R^c: red cone and green hypanthium.
R^s: intensely reddened stems.
r^c: buds free from red pigment.

1) The haploid chromosome number in most *Oenotheras* is 7. (Vide TISCHLER, loc. cit.)

$\begin{matrix} L_1-l_1 \\ L_2-l_2 \end{matrix} \}$: normal (vital)—lethal zygotes.

$S-s$: yellow—sulfur-colored flowers.

$Ls-ls$: normal (vital)—lethal sperms.

$Le-le$: normal (vital)—lethal eggs.

$F-f$: flat—revolute leaves.

$C-c$: normal—*columnaris* type in which the basal branches of *Lamarckiana* are suppressed.

$Np-np$: narrow—broad leaves.

As to the interrelations between these genes, the following results have been given :

1) Of these, the four genes, R^h , R^s , R^c and r^c , form a system of quadruple allelomorphs.

2) The gene f occupies a nearby locus with the R -series. For example, the backcross of $(r^c f \times R^s F) \times r^c f$ gave only 2 individuals with the red stems and revolute leaves, among 296 total plants ; while another cross of $(r^c f \times R^h F) \times r^c f$ gave typical linkage ratios with crossing over to an extent indicated approximately by the ratios 2.45 and 3.08 per cent.

3) There was a crossover value between R^h and n of about 9 units. A similar result was also obtained in crosses involving R^c and n .

4) Of the genes n and s , there was a ratio of crossing over variously calculated as 4.7, 5.9, 6.2 or 9.2 per cent.

5) The linkage value of s and R^s was about 26 per cent. In crosses involving R^h and n the crossing over percentage was calculated as 8.7 (in the coupling type) and 6.1 (in the repulsion type).

In a later publication (1933), SHULL further reported the discovery of a new mutant called '*vetaurea*' having pale old-gold flowers. It proved to be a simple recessive to the normal yellow. Another mutant called '*supplena*' with supernumerary petals and modified pistils was found to be closely linked with the gene for *vetaurea* and independent of linkage groups I and II (*brevistylis*). It is now stated that these two genes form the third linkage group in *Oenothera*.

Oryza sativa¹⁾

COLOR INHERITANCE

Grain. According to VAN DER STOK (1927), HECTOR (1930),

1) Detailed reviews of literature on the inheritance in *Oryza* were made by IKENO (1938) and YAMAGUCHI (1941). It is recommended to refer to these papers for further informations.

and PARNELL *et al* (508, 944), there is a monogenic difference between red and white. In most cases red is completely dominant and segregates independently of the color in other vegetative parts of the plant. HECTOR (911) notes, however, two cases where the F_2 segregation was 1 red : 2 pale red : 1 white, and in one of these, the color in the grain proved to be due to either the same gene responsible for color in the ligule or to a gene completely linked with it.

As to gray-brown color, PARNELL *et al* (508) found in natural hybrids that it is a simple recessive to red ; in other cases, however, the segregation of these characters is more complicated. In a later publication (944), the same authors have reported an interesting cross between gray brown and white, both having unpigmented vegetative parts. The F_1 plants were red, having purple vegetative parts, and in F_2 five groups appeared in a definite ratio, viz.,

3 pigmented (9 red : 3 white) : 1 unpigmented (9 red : 12 gray-brown : 7 white).

For explanation, the authors assumed that the production of purple pigmentation is caused by the presence of two complementary genes, **A** and **N**, and the gene for red grain, **R**, affects only in the presence of **A**, and gives gray-brown in its absence.

Hence the scheme of genes is :

ANR	red	}	'pigmented,'
ANr	white		
AnR	red	}	'unpigmented.'
aNR	gray-brown		
anR	" "		
Anr	white		
aNr	" "		
a n r	" "		

A similar result was found by NAGAI (822), who obtained in F_2 of a cross between reddish brown and white, a ratio of 9 reddish brown : 3 yellowish brown : 4 white. In this case the yellowish brown was not found in the purple awn plants, thus indicating that there is a linkage relation between the genes for the purple awn and for the reddish brown grain.

KATÔ & ISHIKAWA (801) also recognized reddish brown and white to be either monogenically or digenically different from each other. Further an interesting cross has been reported by the same authors, in which two varieties of white, when crossed, gave reddish brown in F_1 and three phenotypes, reddish brown, yellowish brown and white appeared in F_2 . These results were explained on a 3-gene basis (**A**, **B**

and C), thus **ABC** resulting in reddish brown, **AB** in yellowish brown and all other combinations in white.

With respect to gold color, PARNELL *et al* (944) found red dominant to gold, which in turn behaves as a dominant over yellowish. The scheme of genes was represented as: **RI**, red; **ri**, slightly reddish; **Ri**, gold and **ri**, yellowish.

For purple color, the same authors found that purple behaved as a simple dominant character over white in one cross, and purple $\times$ red gave purple-red in F_1 , showing segregation in F_2 into purple, red and white in a ratio of 12 : 3 : 1. The gene for purple, **P**, was assumed: **PR** or **Pr**, purple; **pR**, red and **pr**, white. The purple rice character did not appear to be affected by the gene **I** as in the red rice character.

Awn. As regards the awn color, the following pairs of colors are known to be monogenically different from each other, the first mentioned members being dominant to the latter: red and colorless (KATÔ¹⁾; HECTOR, 445); black and reddish brown (HOSHINO, 409); purple and red (KATÔ; NAGAI, 822); brown and colorless (NAGAI, 822). Dihybrid segregations have been shown by KATÔ in the following crosses:

- 1) Red $\times$ white $\rightarrow F_1$, red $\rightarrow F_2$, 9 red : 7 white.
- 2) Red $\times$ white $\rightarrow F_1$, purple $\rightarrow F_2$, 9 purple : 3 red : 4 white.
- 3) White $\times$ white $\rightarrow F_1$, red $\rightarrow F_2$, 9 red : 7 white.
- 4) Purple $\times$ white $\rightarrow F_1$, purple $\rightarrow F_2$, 9 purple : 3 red : 4 white.

From these results, the following scheme of genes may be given (**C** = a chromogen-gene; **R** = a red-gene in the presence of **C**; **B** = a purple-gene in the presence of **C** and **R**):

CRB purple,
CRb red,
 Other combinations white.

On the other hand, NAGAI (822) made a cross between brown and colorless, and obtained in F_1 red. In F_2 three phenotypes, red, brown and colorless occurred in a ratio of 9 : 3 : 4 respectively. From these results and further the fact that purple is a simple dominant to red, NAGAI assumed the following four genes concerning the color of the awn; **C** = a chromogen-gene, **O** = a chromophelin-gene, converting the chromogenic substance to the brown pigment, **R** = a red anthocyanin-gene in the presence of **C**, and **R'** = a purple anthocyanin-gene in the

1) The extensive work carried out by Dr. KATÔ is summarized in detail in an address by Dr. ANDÔ (Bull. Dept. Agr. Jap. 2 : 1—102, 1916).

presence of **C** and **R**. The genes **C** and **O** were supposed to be completely linked, or to constitute a single gene complex.

Hence we have :

$\widehat{\text{CORR}}'$ purple,

$\widehat{\text{CORr}}'$ red,

$\widehat{\text{COrR}}'$ }
 $\widehat{\text{COrr}}'$ } brown,

Combinations without $\widehat{\text{CO}}$. . . white.

Glume. HECTOR (291) reports that red color in the glume is a simple dominant to white, while THOMPSTONE's results (423) with Burma Paddy point to the reverse, white being dominant to red.

KATÔ obtained, from a cross between two colorless varieties ('Shin-riki' × 'Sekitori'), red in F_1 and a ratio of 9 reds to 7 colorless in F_2 , suggesting that the red color depends upon the presence of two genes, **C** and **R**. Further KATÔ made a cross, dark gray × reddish brown, which gave in F_1 purple, and showed segregation in F_2 purple, reddish brown, dark gray and white in a ratio of 9:3:3:1 respectively. In another cross, dark gray × orange-streaked, KATÔ obtained in F_1 dark gray and in F_2 a ratio of 9 dark gray : 3 dark orange-streaked : 3 white (pale yellow) : 1 orange-streaked. For explanation of these results, the following four genes have been established : **C**, a chromogen-gene ; **G**, a gray-gene ; **R**, a gene giving red with **G** ; and **H**, an inhibitory gene for orange-streaking.

Later, PARNELL *et al* (508, 944) found that in some cases gold color behaves as a simple recessive to colorless ; in other cases, however, gold proves incompletely dominant to colorless, and also that blackish brown which affects the furrows more particularly is dominant to colorless. As regards the distribution of color in the glume, they could identify a dominant gene which localizes the pigments in the center of the glume, the apex and base of which remaining entirely green. Further the same authors report that yellow-brown glumes are recessive to those ripening black and evidently depend on two genes, the F_2 segregation being 1 : 3 or 7 : 9.

NAGAI (822) describes a type, in which purple color in the glume is localized in streaks from the tip downward on the yellow ground color. This type, when crossed with brown, gave a new type in F_1 , namely, the self purple on the brown ground color. In F_2 four phenotypes—self purple on brown, localized purple on yellow, brown and yellow—were

obtained in a ratio of 9:3:3:1. Two genes have been established: **P'** = a gene for the purple pigment, **B** = a gene for the brown ground color. Since the purple pigmentation in the glume is always associated with the brown ground color, it appears that either **B** has a simultaneous action extending the purple pigment to the entire surface of the glume or that the phenomenon is due to another gene which is completely linked with **B**.

Later, HECTOR (911) found yellow glumes dominant to red. Moreover he confirmed the result obtained by PARNELL that the ripening black character is dominant to yellow-brown, and added a fact indicating that yellow brown is recessive to ripening red. As regards another color, brick-red, the same author has shown it to be recessive to white, confirming the result by THOMPSTONE (423).

On the other side, YAMAGUCHI (860, 1337) made a cross between dark blackish violet and yellowish white. F_1 plants had blackish violet glumes, somewhat paler than that of the parent, and gave in F_2 the following five phenotypes, namely (1) blackish violet, (2) blackish violet at the apex of glumes, (3) reddish brown, (4) reddish brown at the apex of glumes, and (5) colorless (yellowish white). These plants appeared in a ratio of 27:9:9:3:16 respectively, clearly indicating that three genes are concerned in the glume color. These genes were designated as **B**, **R** and **S**, the combinations of these being as follows:—

BRS blackish violet,
BrS blackish violet at the palea-apex,
bRS reddish brown,
brS reddish brown at the palea-apex,
 Other combinations . colorless.

It is to be noted that the gene **S**, according to YAMAGUCHI, is not most likely a simple gene, but may be analyzed into two elementary ones, **S**₁ and **S**₂; **S**₁ governing the red color in the paleae apex, while **S**₂ causing the same pigment in the entire empty glume.

Color of the Leaf and other Vegetative Parts. With respect to the leaf-color, crosses between purple and colorless (green) give purple in F_1 , and show segregation in F_2 in a ratio of 3:1 or 9:7, suggesting the two distinct genes of pigmentation (KATÔ; PARNELL *et al.*, 944), or 27:37 which indicates the presence of three genes (TAKEZAKI, 844, 1084).

Intimate connection was found between colors in the glume apex, leaf-sheath and stigma by HECTOR (445). The Indian varieties studied may be broadly classified as follows:

- I. Leaf-sheaths, glume apices and stigma colored,
- II. Same as (I) except that stigma is colorless,
- III. Same as (I) except that leaf-sheaths are colorless,
- VI. Apices of glumes alone contain any color.

Class I is the commonest group, although in Japan the colorless stigma with green leaf-sheaths is the most common type. Classes III and IV are the rarest types. Colors in these parts, according to him, are due to the interaction of several genes; namely the color in the leaf-sheaths and glume apex depends on a color gene acting on a chromogen base **C**, and the purple color of the stigma is caused by the action of a further gene **P** in the presence of **C** and **R**. In certain cases, the stigma color was found to be due to more than three genes.

According to PARNELL *et al* (944), the purple lining of internodes, purple glumes, purple stigma, purple axil (purple-coloring of the epidermis on the inside of the sheath)—each character, considered separately, is dominant to the character 'unpigmented'; considered together, however, these characters showed that (1) the purple internode and the purple glume are associated with each other, (2) the purple stigma is coupled with the purple axil, but (3) the purple lining of the internode and the purple glume do not co-exist with the purple stigma and the purple axil.

Recently, YAMAGUCHI (1337), in certain crosses, has recognized that the blackish violet color of the glume or glume apex is always associated with the purple color in the internode, leaf, leaf-sheath, ligule and stigma, while in plants with red glumes the color is considerably indistinct, sometimes obscure, and in those with colorless glumes these parts are also colorless.

Besides these, PARNELL *et al* (944) reports that dark purple-coloring of the pulvinus and auricle is dominant to green, and is clearly independent of the above mentioned group in segregation.

SOME MORPHOLOGICAL CHARACTERS

Size, Form and Weight of the Grain. VAN DER STOK (122, 123, 1007) crossed a very small-grained line of the Minuata-group with a normal long-grained line of the Communis-group. F_1 was about intermediate as to size; in F_2 occurred a continuous series, passing on from the Minuata-type to the Communis-type. By grouping the F_2 grains into three classes: Minuata-type, intermediates and Communis-type, a ratio of 1:2:1 was obtained.

Later, TERA0 (963) reported that a large-grained plant which oc-

occurred as a mutant, behaves as a recessive to the normal, showing segregation in F_2 in a ratio of 1:3. The recessive gene, however, is occasionally transformed by positive mutation into the dominant allelogene ($a \rightarrow A$).

PARNELL *et al* (944) found a close correlation between the glume-color and the shape of the grains. The ripening gold (and ripening furrows) types are distinctly long and narrow, while the dark gold (and dark furrows) types are shorter and broader. Crosses were made between the dark gold and ripening gold plants, the mean length/breadth value of the former being 3.00, and that of the latter 3.85. The F_1 grain was intermediate, having the average value of 3.36. In F_2 three types were found: 1 dark gold (3.14): 2 medium gold (3.34): 1 ripening gold (3.88), representing the extracted dark gold, heterozygous intermediates, and extracted ripening gold respectively.

As to grain weight, the same authors (944) made a cross, in which the dark gold and ripening gold parents averaged 2.145 g and 1.755 g per 100 grains respectively. Grains were intermediate in weight in F_1 , being 2.050g, and segregation occurred in F_2 in a ratio of 1 dark gold (2.144g): 2 medium gold (2.075): 1 ripening gold (1.910g).

Awning. According to HOSHINO (409), KATÔ, MENDIOLA (937) and YAMAGUCHI (1337), awning is practically dominant to the lack of awns. The segregation in F_2 takes place in a ratio of 3:1 or in some cases 15:1 (KATÔ). An exceptional case, however, has been reported by VAN DER STOK (122, 1007), in which the awnless character behaves as a dominant over the weak awning.

Recently, NAGAI (1336), in a mutant form, called 'staminoidal sterile', has established two genes for awning; namely **N**, a gene for the development of the awn, and **B**, a modifying gene for the development of the awn. The gene **B** has no effect without **N**. According to this scheme, the genic formulae are:

NB		full-awned,
Nb		medium (NN)- or rare (Nn)-awned,
nB	}	 awnless.
nb		

Hence the cross, medium-awned $\times$ awnless, gives full-awned in F_1 , and segregates in F_2 four classes of phenotypes, namely, full-, medium-, rare-awned and awnless in a ratio of 10.75:1:2:2.25. In this case all **nn**-plants are staminoidal sterile and roll-leaved.

Dwarfishness. According to PARNELL *et al* (944), a dwarf race of rice-

plants is recessive to the typical one, and segregation in F_2 indicates that it is monogenic. SUGIMOTO (1982) reports, however, a dominant dwarf plant besides the ordinary recessive race. This plant, according to his opinion, has appeared as a monogenic heterozygote, due to a mutation, having dominant nature.

Later, AKEMINE (1934) described three dwarf types: 1st type ('Ebisu') with an average height of about 69 cm., 2nd type ('Daikoku') with 20 cm., and 3rd type ('Kodaikoku') with 22 cm. The former two types behave as simple recessive characters to the typical form. Crosses between them give the typical plant in F_1 , and showed segregation in F_2 in a ratio of 9 (normal) : 3 (1st type) : 3 (2nd type) : 1 (3rd type). Thus the 3rd type occurs as a segregate only. These results were explained by the assumption that the typical race is due to the presence of two genes, **A** and **B**, an absence of either of the genes resulting in the 1st or 2nd type.

Recently, NAGAI (1936) also reports a recessive dwarf of mutative origin. A peculiar mode of inheritance, however, has been observed in this mutant; that is, mutant individuals gradually increase in the subsequent generations, viz., the ratio of the number of mutated and normal gametes changes from generation to generation toward the equality of the number of both kinds of gametes. Similar phenomena have been recognized in his compact-panicle mutant.

SOME PHYSIOLOGICAL CHARACTERS

Sterility. TERAU (1945) reports a semi-sterile race of mutative origin. This race proves to be always heterozygous, showing segregation, when selfed, into fertiles and semi-fertiles in a ratio of 1 : 1, the former breeding true and the latter repeating the same mode of segregation in later generations. For explanation, he supposes that semi-sterility is due to a sex-linked lethal gene, **a**, causing the death of the female gametes, but not affecting the male, and its allelogene, **A**, behaves quite normally.

Later, NAGAI (1936) found another kind of partial sterility which proves to be nearly constant. These plants, however, throw by reversion a small number of fertile plants.

As to complete sterility, NAGAI (1936) records three kinds of mutants, viz., (1) 'staminoidal sterile' in which female gametes are completely sterile, (2) 'awned sterile' which is due to complete sterility of male gametes, and (3) 'paleaceous sterile' which is sterile in both sexes. The staminoid steriles are also characterized by the rolling of the leaf, namely its leaves are rolled at the base of the blade so that they are

drooped downward instead of holding the upright position as in the normal case. The awned steriles have, however, normal leaves, and are full-awned. The paleaceous steriles are roll- or normal-leaved. All these mutants prove recessive to the normal in inheritance. Genes assumed are as follows :

N—n—n': a series of triple allelomorphs; **N**=normal, **n**=staminoidal sterile, and **n'**=roll-leaved fertile.

S—s: in the presence of **N**, **s** gives the awned sterile.

G—g: in the presence of **N** or **n'**, **g** gives the paleaceous sterile.

Genic formulae for these sterile mutants are given below :

NGS		Normal-leaved fertile,
nGS	}	 Roll-leaved staminoidal sterile,
ngS		
nGs		
ngs		
NgS		Normal-leaved paleaceous sterile,
n'gS		Roll-leaved paleaceous sterile,
NGs		Normal-leaved awned sterile.

According to him, two pairs of genes **N—n—n'** and **G—g** are closely linked together, and usually no crossover takes place between them.

Time of Shooting. HOSHINO (409) made a cross of an early shooting variety ('Akage') with a late one ('Kuro-Bôzu'). The parent used averaged 83.8 and 113.2 days respectively, from soaking to shooting, the parental average being 98.5 days, while the F_1 gave an average of 94 days from soaking to shooting. Hence the shooting time of F_1 is intermediate between those of both parents, but inclines rather towards that of the early parent. The F_2 generation equalled the combined range of the parents. The author suggests that the three multiple genes **A**, **B** and **C** will explain the results.

On the other hand, NOMURA & YAMAZAKI (1293) obtained F_1 plants shooting a few days later than the late parent, and in F_2 a monogenic segregation, viz., 1 early : 3 late, although the early and the late plants of each group are on average somewhat earlier and later than the respective parents. For interpretation, the authors draw up a trigenic basis. A gene **A**, in the homozygous condition, gives the shooting time about 9 days later than that of the **aabbcc** plants, while in the heterozygous condition it represents an intermediate effect. Genes **B** and **C** prolong the time 3 days and 23 days respectively. Further a complementary effect exists between **A** and **C**, the combination of which results

in a longer time of shooting than the additional effect of both genes. In **aabbcc** plants the shooting time was found to be about 94 days in average.

OTHER CHARACTERS

With respect to the inheritance of other characters in rice plants, a short summary is given here in TABLE XIV.

TABLE XIV.—INHERITANCE OF SOME CHARACTERS IN RICE.

Contrasted characters	F ₁	F ₂	Authors
High—low stature	High stature almost completely dominant	Continuous gradations (Multiple genes)	KATO
Long—short glume	Short	3 short : 1 long	{ VAN DER STOK (1007) PARNELL <i>et al</i> (508)
Normal—compact panicle	Normal	3 normal : 1 compact	
			NAGAI (1336)
Long—short panicle Thick—thin stem	Long panicle and thick stem almost completely dominant	Continuous gradations (Multiple genes)	KATO
Amount of tillering Compact—loose grain arrangement Broad—narrow leaf		Intermediate	Continuous gradations (Multiple genes)
Grains not readily falling—readily falling	Grains not readily falling	3 not readily falling : 1 readily falling	KATO
Starchy—glutinous endosperm	Starchy	3 starchy : 1 glutinous	{ PARNELL <i>et al</i> (944) VAN DER STOK (1007) IKENO (348) and others.
Pure glutinous plants have glutinous pollen, and starchy plants starchy pollen.			
YAMAGUCHI (1332) reports, however, that the dominance of the starchy endosperm is not complete.			
Susceptible to <i>Leptosphaeria Cattanei</i> —immune	Susceptible	3 susceptible : 1 immune	KATO
Susceptible to <i>Piricularia oryzae</i> —immune	Immune	3 immune : 1 susceptible	SASAKI (950)
Long—short hairs on the leaves	Long		VAN DER STOK (1007)

LIST OF GENES IN *Oryza* AND LINKAGE RELATIONS

The following is a list of genes of the rice plant after YAMAGUCHI (1941), who made a careful review of earlier investigation :

- A** : normal fertility ; **a** : semi-sterility. (TERAO's **A**).
Au : colored auricle. (HECTOR).
B : converts reddish brown glume color into blackish violet. (NAGAI's **R'** ; YAMAGUCHI's **B**).
Bd : conjointly with **N** causes the full development of the awn. (NAGAI's **B**).
Bn : brown awn-coloring. (NAGAI's **O**).
Br : brown ground coloring of the glume. (NAGAI's **B**).
Bs : purple leaf-sheaths. (HECTOR).
C : chromogen for anthocyanin.
C' : chromogen for red grains. (NAGAI's **C'** ; KATÔ & ISHIKAWA's **C**).
D : normal growth ; **d** : dwarf. (AKEMINE's **A** ; NAGAI's **D**).
D₁ : normal growth ; **d₁** : dwarf. (AKEMINE's **B**).
D' : dwarfishness ; **d'** : normal. (SUGIMOTO).
E : even-coloring of glumes ; **e** : marble-coloring. (PARNELL's **E**).
El : elliptic grains. (PARNELL).
F₁, F₂, F₃ : shooting time. (HOSHINO, NOMURA & YAMAZAKI's **A, B, C**).
G : dark gold glumes. (PARNELL's **G**).
Gl : normal ; **gl** : large-grained. (TERAO's **A**) ;
Gr : dark gray glumes. (KATÔ's **G**).
Gs : normal ; **gs** : paleaceous sterile. (NAGAI's **G**).
I : dark furrow of the glumes. (PARNELL's **I**).
J : short ; **j** : long glumes. (PARNELL).
K : normal ; **k** : compact panicle. (NAGAI's **K**).
K₁ : black glumes. (PARNELL).
L : colored lining of internodes. (PARNELL, HECTOR's **L**).
Lg : colored ligules. (HECTOR).
M : starchy endosperm ; **m** : glutinous. (TAKAHASHI's **U** ; YAMAGUCHI's **M**).
N : normal ; **n** : staminoid sterile. (NAGAI's **N**).

O': brown grains. (NAGAI's **O'**; KATÔ & ISHIKAWA's **A**; PARNELL's **R**).

Og: inhibits orange-streaking of glumes. (KATÔ's **H**).

P: purple grains. (PARNELL's **P**).

Pb: piebald pattern of glume colors. (PARNELL's **P**).

Pl: purple leaves. (KATÔ's **P**; TAKEZAKI's **A**).

Ps: purple stigma. (HECTOR's **P**, PARNELL's **S**).

Pu: colored pulvina. (HECTOR).

R: reddish brown glumes. (KATÔ, YAMAGUCHI's **R**).

Rg: red awns. (NAGAI's **R**).

S: reddish apex of the glume; probably to be analyzed into **S**₁ and **S**₂. (YAMAGUCHI's **S**).

St: normal; **st**: male-sterile. (NAGAI's **S**).

T: localizes the pigments in the center of the glume. (PARNELL's **T**).

W: grain-weight. (PARNELL).

Wd: resistance to *Piricularia*. (SASAKI).

Z: white glumes; **z**: brick-red glumes. (HECTOR).

Although considerable work has been done on inheritance in rice, comparatively few cases of linkage have been shown definitely. At present the following four groups of linked genes are known, YAMAGUCHI's notation being adopted here¹⁾:

Group I. **G—L**, with crossovers of 16.6%. PARNELL (508).

Group II. **S—M**, with crossovers of 20–22%. YAMAGUCHI (860, 1337). TAKAHASHI (1083).

Group III. **Lg—R(?)**, with crossovers of 12.5%. HECTOR (911).

Group IV. **N—G**, usually with no crossovers. NAGAI (1336).

Oxalis corniculata

NOHARA (415) reported that the presence of the purple color in the eye of the corolla and in the leaves is governed by a single gene, and is dominant to its absence. The intensity of pigmentation in **F**₁ was found to be intermediate, giving the segregation in **F**₂ in a 1:2:1 ratio.

1) The haploid chromosome number in *Oryza sativa* is 12. (Vide TISCHLER, *loc. cit.*)

Oxalis rosea

UBISCH (1094, 1317) explained her results on the inheritance of flower color on a digenic basis, **F** being the basic gene for color and itself producing light rose, and **R** converting it into rose; thus **FR**=rose, **Fr**=light rose, **fr** and **fr**=white.

With respect to the inheritance of heterostylism (*Oxalis rosea* being a trimorphic plant), two genes were assumed, **A** for short-style and **B** for mid-style; thus **ab**=long, **aB**=mid, **Ab** and **AB**=short. The cross between rose longs (**Ffaabb**) and white mids (**ffaaBb**) gave rose mids, rose longs, white mids and white longs in a 1:1:1:1 ratio. The cross between rose longs (**Ffaabb**) and rose mids (**FfaaBb**), however, revealed a peculiar relation of the gene **F** to the gene **A**. It gave rose shorts (**FFaaBb**, **Ffaabb**), rose mids (**FfaaBb**), rose longs (**Ffaabb**), white mids (**ffaaBb**) and white longs (**ffaabb**) in a ratio of 2:2:2:1:1. Hence we may suppose that in the homozygous condition of **F**, **aa** behaves as if it were **Aa** or **AA**.

Oxalis valdiviana

BARLOW (272, 982) has published the results of experiments on the inheritance of the three heterostyle forms in this plant. It was stated that long $\times$ short and long $\times$ mid (and their reciprocals) gave both parental forms in a ratio of 1:1, while mid $\times$ short gave longs, mids and shorts in very complex ratios.

UBISCH (850, 1094, 1317) discussed the results of BARLOW, and explained them on a digenic scheme;

ab		long,
aB		mid (in general, aaBb),
Ab	}	 short (in general, Aabb).
AB		

Papaver Rhoeas

Flower Color. SHULL (265) reported that the presence of a white margin of the petals is a character dominant to its absence. The supposed color inhibitor was evident only in crosses of at least one red-flowered or striated plant. Certain whites were found to be dominant in crosses with red or striated plants, but the same whites were recessive in crosses with pink or red-orange plants. Some red-flowered varieties

crossed together gave whitish offspring. These results suggest that at least two genes are necessary for inhibition, and also that these genes act on the red color only.

BECKER (526) made some observations on the variation of the marking at the base of petals. Best developed marking consists of two parts, spot usually elongated radially (designated by + s) which is capped toward the outside by a wide white spot (designated by + w). Petals may occur (1) without markings (-s, -w), (2) with black bar only (+s, -w), (3) with white spot only (-s, +w), or (4) with both markings (+s, +w). The combination +s +w appears in outer petals only if they are also in the inner petals. But +s +w may occur in inner petals even though lacking in the outer. Two inhibitory genes were assumed, H_1 acting only on inner petals, and H_1 and H_2 affecting both inner and outer petals. Further simplex doses of genes for +s and +w are supposed to dominate over H_1 , while duplex combinations dominate over both H_1 and H_2 .

RASMUSON (732) made crosses of *Rhoeas* with *laevigatum*. The results obtained were explained as a digenic difference. S stands for dark (black) eye-spot, and is epistatic to the white gene W; the combination sw results in unspottedness. A similar relation was obtained by KAJANUS (636), who crossed black-spotted with white-spotted varieties within the *Rhoeas* group.

Other Characters. RASMUSON (732) made a cross between a *Rhoeas* form with divergent hairs at the peduncle with another one having appressed hairs. In F_1 a segregation in a 1:1 ratio was obtained. To judge from the species hybrid, *Rhoeas* $\times$ *dubidum*, he concluded that the divergent hairs may be dominant. The same author showed also the dominance of yellow latex over white, and the green color of the leaves over yellowish green. In both cases, a monogenic segregation was observed in F_2 .

Papaver somniferum

Flower Color. DE VRIES (8, 56) and HURST (76) showed the simple dominance of the basal spot on the petals over its absence. HURST further states that color in the rest of the petal is dominant to white and that purple is dominant to red.

KAJANUS (638) postulates two color genes, R for red and V for violet. The gene R makes the petals colored on the upper surface only, and V on both upper and under surfaces. The combination RV pro-

duces red on the upper and violet on the under surface. The absence of both results in colorless petals.

LEAKE & PERSHAD (717) working at the Indian poppy identified the following four color genes :

P : a gene for pink margin and white eye.

R : an intensifier of **P**-effect, which produces a scarlet or crimson margin separated from a white eye by a blue or purple band.

M : a gene for mauve-purple margin and deeper eye.

L : an intensifier of **M**-effect, converting the mauve-purple into a rich magenta-purple.

Heterozygous forms were found to produce considerable variations of intensity of color. The combinations of these genes give the following five groups :

P(R)ML . . . red (**PP**) or crimson-purple (**Pp**)—Full color group.

P(R)Ml . . . pink-purple or red-blue eye (**PP**) or blue-pink eye (**Pp**)—Dilute color group.

TABLE XV.—INHERITANCE OF FLOWER COLOR IN **Papaver somniferum**. A summary of the results obtained by.
MIYAKE & IMAI (1056).

Contrasted color	F ₁	F ₂	Genes involved
Red—purple	Dark red	1 red : 2 dark red : 1 purple	R
Red—red, white eye	Red	3 red : 1 red, white eye	D
White—red, white eye	Pale red	1 red, white eye : 2 pale red : 1 white	
” ”	White	3 white : 1 red, white eye	I
White—purple	Purple	3 purple : 1 white	
White—red	Dark red	3 red : 6 dark red : 3 purple : 3 white eyed red : 1 white	RRDD, RRdD, RrDD, RrDd, rrDD, rrDd, RRdd, Rrdd, rrdd.
Red, white eye—purple, } or red—white }	Dark red	3 red : 6 dark red : 3 purple : 1 red, white eye : 3 white	DDiiRR, DdiiRR, DDi iRr, DdLiRr, DDiiRr, DdLiRr, ddiiRR, ddiiRr, ddLiRr, ddLiRr.
White—white	White	3 white : 1 ‘Sakura’ (pink) ‘Sakura’ further segregates into ‘Sakura’ and white in a 3 : 1 ratio.	H S

TABLE XVI.—INHERITANCE IN *Papaver somniferum*.

Contrasted characters	F ₁	F ₂	Authors
<i>Flower</i>			
Large—small petals	Large	Approximately 3 large : 1 small	LEAKE & PERSHAD (717, 929)
Green - striped — non-striped petals	Non-striped	3 non-striped : 1 striped	KAJANUS (638)
The hetrozygote may have very faint stripes. The gene concerned, U .			
Single—double flowers	Single prevails or dominates	3 single & fairly full : 1 double	KAJANUS (638)
The gene concerned, E . The effect of this gene is heterozygously weakened. In only one exceptional case, KAJANUS observed the reverse in F ₂ , in which 3 double to 1 single occurred.			
Laciniated—entire petals	Intermediate	Emerginate, further constant; entire, further constant; laciniated & entire, further segregating	FRUWIRTH (1142)
		Entire & laciniated, further segregating ; e-marginate & laciniated, further segregating into 3 laciniated : 1 entire	KAJANUS (638)
		3 laciniated : 1 entire	LEAKE & PERSHAD (717)
According to KAJANUS, two genes influence the dividing of the petals ; S determines it, while G inhibits it. In the heterozygotic condition G tends to over-rule S , hence the petals are entire, or slightly indented.			
Dark—whitish anther color	Dark	Segregation	DE VRIES (13)
Early—late flowering time	Intermediate	Segregation, early flowering time being prevalent	PRZYBOROWSKI (946)
<i>Seed</i>			
Dark—white	Dark	Segregation	DE VRIES (13)
Gray—white	Gray	Segregation	FRUWIRTH (1142)
Gray—white	Gray	Gray, gray-violet, rose, yellow & white	PRZYBOROWSKI (946)
According to PRZYBOROWSKI, the following genes are concerned in the seed color ; V for rose, G for yellow, I for intensification of V . Thus VIG gray, VIg gray-violet, Vi(G) rose, v(I)G yellow, v(I)g white. Another gene, R , is responsible for another rose. R differs from V in being hypostatic to G .			

Contrasted characters	F ₁	F ₂	Authors
Blue—white Straw—white	Blue Straw	9 blue : 3 pink : 1 white 3 straw : 1 white	} LEAKE & PERSHAD (929)
LEAKE & PERSHAD assumed the following three genes: S for straw, P for pink and B for blue. In the absence of P and of B, the homozygous SS type is distinguished from the heterozygous by the greater intensity of the color. In the absence of S and of B, PP can not be distinguished from Pp. S and B are linked.			
<i>Seedling</i> Violet—green	Violet	Segregation	ERUWIRTH (1142)
<i>Other Characters.</i> DE VRIES (13) found that the transformation of stamens into supernumerary carpels is recessive to the normal formation of ovary, in F₂ showing segregation. The same author (8) mentioned that the tall form is dominant to the lower form. PRZYBOROWSKI (946) also made some observations on form and size of capsules, branching habit and size of petals. The genes involved have not as yet been determined.			

PRm(L) . . . red-purple (**PP**) or purple (**Pp**) white eye } —White-eyed group.
Prm(L) . . . full pink (**PP**) or light pink (**Pp**) white eye }
p(R)ML . . . magenta-purple } —Purple group.
p(R)MI . . . light mauve-purple }
p(R)m(L) . . . pure white—White-flowered group.

They also state that white-eyed varieties have white seeds, and colored-eyed varieties colored seeds (pink, deep or bright blue or brown, or straw-colored).

PRZYBOROWSKI (946), from a cross of a dark violet-eyed (gray-seeded) variety with a white-flowered (white-seeded) variety, found in F₂ three types: dark-eyed (gray- or gray-violet-seeded), pale-eyed (rose-seeded) and white (yellow-, rose- or white-seeded). The numbers obtained were very close to the ratio of 9 : 3 : 4. Two genes were postulated, **V** for pale-violet eye, and **I**, an intensifier of **V**. Thus **VI**=dark-eyed, **Vi**=pale-eyed, **vi** and **vi**=white. These genes have a pleiotropic effect on the color of seeds. (See TABLE XVI.)

ISHIHARA, KÔKETSU & KOJIMA (918) made a cross between violet and white. They obtained violet in F₁ and in F₂ violet, rose-red and white in a ratio of 9 : 3 : 4. Among the rose-red groups there were two types, one of which was dark in color, and proved to be homozygous, and the other light and heterozygous for the color gene. Thus:

AB		violet,
Ab		dark rose-red (AA), or light red (Aa),
aB	}	 white.
ab		

Later MIYAKE & IMAI (1956), from several cross-experiments (See TABLE XV), identified the following series of genes :

- R**: a gene for red margin. In the presence of **D**, **RR** gives red ;
Rr dark red.
D: a gene for purple eye, its absence resulting in white eye.
I: a gene converting white-eyed red flower into white.
S: a gene for 'Sakura' (pink) color.
H: a gene converting 'Sakura' into white.

The authors state that there is a linkage of high intensity between **R** and **I**.

Other Characters. A summary of the inheritance of several other characters investigated in the poppy is given above in TABLE XVI.

Pelargonium zonale

Doubleness of Flowers. BALLARD (522) obtained the following results :

- 1) Single $\times$ single gave 84 singles and 6 doubles ;
- 2) Single $\times$ double gave 59 singles and 74 doubles ;
- 3) Double $\times$ double gave 40 singles and 30 doubles.

Singleness was regarded as a character dominant to doubleness. The nectar tube adnate to the flower stalk did not appear in the double flowers of any cross. It is apparently correlated with singleness.

Chlorophyll Deficiencies. BAUR (157) has shown that the 'aurea' (golden) type is always heterozygous, showing segregation into pure green, 'aurea' and pure yellow in a 1:2:1 ratio. The pure yellows are not capable of assimilating carbon dioxide, and consequently die in the seedling stage, resulting in 1 green : 2 'aurea'.

The same author also reports on the periclinal variegation that plants with green inside and white epidermis and sub-epidermal layers have exclusively white offspring, while plants with white inside and green external layers have exclusively green offspring. Similarly when the external layers are golden, the offspring are greens and goldens, just as when derived from wholly golden plants.

Petunia

Flower Color. WESTGATE (213) made some observations on the inheritance of flower color. Violet-red and white gave an intermediate color in F_1 , and dark colored, intermediate and white in F_2 . MALINOWSKI & SACHSOWA (456), from several crosses, showed monogenic differences between violet and red, lilac and dark rose, red with violet throat and red with white or ivory throat, and lilac with dark violet throat and lilac with light-colored throat, in each case the first given members dominating.

RASMUSON (577) dealt with several forms of *Petunia hybrida* (*P. nyctaginiflora* $\times$ *P. violacea*). A cross, white ♀ $\times$ violet ♂ , showed that deep flower color is dominant to pale, and blue color in anthers (throat blue) is dominant to yellow (throat yellow), showing the normal segregation in both cases. The gene for deep flower color and the gene for blue anther are independently transmitted. He also obtained some evidence indicating that dark violet color in nerves on the outer side of the corolla-tube is monogenically dominant to green.

SACHS-SKALIŃSKA (835, 1215) made crosses between *P. grandiflora* having uniform red violet flowers and two polymorphic plants of *P. violacea* showing the extremes of variability as to color and form of flowers. Uniformity was dominant to polymorphism in F_1 . In F_2 four forms were observed,—plants with large uniform flowers, those with small uniform flowers, those with large polymorphic flowers and those with small polymorphic flowers.

Doubleness of Flowers. The doubleness of *Petunia* is apparently due to a petalody of the stamens, nevertheless anthers containing good pollen are formed. The female organs are usually abortive. SAUNDERS (143, 464), showed that the singles gave no doubles, whether selfed or crossed *inter se*, but the cross, single ♀ $\times$ double ♂ , gave a mixture of singles and doubles in several proportions. An explanation was postulated that the singleness behaves as a dominant, as in *Matthiola*, and that the pollen of singles carries always the single-gene, but the ovules of singles consist of a mixture of singles and doubles.

FROST (393) discussed her data, and gave a new hypothesis that doubleness is a heterozygous dominant, and the variable proportions obtained by SAUNDERS are due to differences in viability of the types.

Later, UBISCH (1094), using flowers exhibiting the lower degrees of doubling and having small but normal ovaries, could hybridize doubles

as the female parents with singles, as well as doubles with doubles. The results from the four different combinations were :

- 1) Single $\times$ single $\rightarrow$ singles only,
 - 2) Single $\times$ double
 - 3) Double $\times$ single
- $\left. \begin{array}{l} 2) \\ 3) \end{array} \right\} \rightarrow 1 \text{ single} : 1 \text{ double},$
- 4) Double $\times$ double $\rightarrow$ 3 double : 1 single.

There was a deficiency of doubles in these ratios, owing to their lower viability and late blooming. Taking the results of SAUNDERS into consideration, the author assumed two dominant genes for doubleness, **F** and **G**, singles lacking either or both of them. Thus the plants used in these crosses were: doubles=**FFGg**, and singles=**FFgg**. Individuals homozygous for both the genes bore more extensively doubled flowers than those of the heterozygotes.

Self-sterility. TERA0 (1089) gives a preliminary account on the inheritance of self-sterility in *P. violacea*. A cross, self-fertile $\times$ self-sterile gave in F_1 self-fertile and self-sterile plants in a 1 : 1 ratio. It is presumed that one of the parents would be heterozygous, and the other homozygous for the gene for self-sterility. Among self-steriles two classes of plants are differentiated, members of each class being inter-fertile, but intra-sterile.

Pharbitis Nil¹⁾

Flower Color and Pattern. MIYAZAWA (568, 569, 819), from a cross between white and deep dark red, obtained light magenta in F_1 and a complex segregation in F_2 . IMAI (797) found that the cross, green-stemmed, white flower $\times$ colored-stemmed, white flower gave in F_1 colored-stemmed colored flower and in F_2 colored flower and white flower in a ratio of 9 : 7. It is clear that the color of flowers is due to the co-operation of two complementary genes, **C** and **R**, a conclusion reached also by TAKEZAKI ('16). It was further found by IMAI (631, 797, 1159) that the difference between dark red and scarlet is monogenic (**A** and **a**).

HAGIWARA (1013), whose results of crossing are tabulated in TABLE

1) The author is greatly indebted to Mr. Y. IMAI and Mr. B. MIYAZAWA who have kindly scanned my manuscript on this plant, and gave many valuable suggestions and criticisms. He is also indebted to Miss. K. YASUI for her help in various ways.

To publications of TAKEZAKI ('16, '18), TANAKA ('15) and TOYAMA ('16) direct access has not been possible; the reference, therefore, is taken from various papers of IMAI, HAGIWARA and others.

TABLE XVII.—THE INHERITANCE OF FLOWER COLOR AND PATTERN
IN **Pharbitis Nil.** A summary of the results obtained by
HAGIWARA (904, 905, 1013).

Contrasted characters	F ₁	F ₂
<i>Corolla Color</i>		
White—scarlet	Scarlet	3 scarlet : 1 white
Scarlet—purple	Purple	3 purple : 1 scarlet
White—purple	Purple	9 purple : 3 scarlet : 4 white
Purple—blue	Blue	3 blue : 1 purple
Dark red—purple	Blue	9 blue : 3 purple : 4 dark red
Purple—purple	Blue	9 blue : 6 purple : 1 scarlet
White—dark red	Blue	81 blue : 54 purple : 9 scarlet : 48 dark red : 64 white
White—spotted	Totally colored	9 colored : 3 spotted : 4 white
<i>Tube Color</i> (fl.=flower ; tb.=tube ; col.=colored)		
White fl., white tb.—color- ed fl., colored tb.	Colored fl., colored tb.	9 col. fl., col. tb.: 3 col. fl., partial- ly col. tb.: 3 white fl., col. tb.: 1 white fl., white tb.
Col. fl., col. tb.—white fl., light col. tb.	Col. fl., col. tb.	9 col. fl., col. tb.: 3 col. fl., light col. tb.: 3 white fl., col. tb.: 1 white fl., light col. tb.
White fl., light col. tb.— white fl., white tb.	White fl., col. tb.	3 col., tb.: 1 white tb.
White fl., slight tb.—col. fl., col. tb.	Col. fl., col. tb.	9 col. fl., col. tb.: 3 col. fl., slight tb.: 3 white fl., col. tb.: 1 white fl., light tb.
Col. fl., col. tb.—col. fl., light col. tb.	Col. fl., col. tb.	3 col., tb.: 1 light tb.
Col. fl., white tb.—col. fl., light tb.	Col. fl., light tb.	3 light tb.: 1 white tb.
Col. fl., col. tb.—col. fl., white tb.	Col. fl., col. tb.	Segregation indicating a partial linkage between T ₁ and T ₂ .
<i>Corolla Pattern</i>		
'Fukurin'—normal	'Fukurin'	3 'Fukurin' : 1 normal
" "	Normal	13 normal : 3 'Fukurin'
'Star'—'Fukurin'	Intermediate	1 'Star' : 2 intermediate : 1 'Fuku- rin'
White—'Fukurin'	'Fukurin'	3 'Fukurin' : 1 white
" "	"	9 'Fukurin' : 3 totally col. : 4 white
White—'Star'	'Fukurin'	4 white : 7 'Fukurin' : 2 inter- mediate : 3 'Star'
" "	"	16 white : 12 totally colored : 27 'Fukurin' : 6 intermediate : 3 'Star'

XVII, classified all flower colors of this plant into four groups: blue, purple, scarlet and dark red. The results obtained led him to assume the following genes:

- $\begin{matrix} \text{C} \\ \text{R}^{1)} \end{matrix} \}$: basic genes for the production of anthocyanin, in the absence of either or both of which the flower is white.
A: gene causing scarlet color.
Pl: gene converting scarlet into purple.
B: a bluing gene, effective only in the presence of **C**, **R**, **A** and **Pl**.

Thus we get:

CRAPIB blue,
 $\left. \begin{matrix} \text{CRAPIb} \\ \text{CRApIB} \end{matrix} \right\}$ purple,
 CRApIb scarlet,
 $\left. \begin{matrix} \text{CRaPIB} \\ \text{CRaPlB} \\ \text{CRaPIb} \end{matrix} \right\}$ dark red,
 CRapIb
 Other combinations . . . white.

Besides these anthocyanin groups, there exists another: yellow, which is due to plastid pigment. IMAI (797) and HAGIWARA (1146) found that the yellow color is caused by a single gene **Y**, its absence resulting in white.

In a later publication (1273), IMAI reported still another type of yellow (cream) flower, which gives on selfing a small number of ever-sporting colored plants, and is also vegetatively inconstant bearing rarely striped flowers, or less frequently even entirely colored ones. This type behaves as a simple recessive to colored flowers, though the

1) The original symbols of these three genes, **R**, **A** and **Pl**, are **K**, **R** and **P** respectively. But **K** had been already used as the symbol of the dominant allelogene for the dragon-leaf by IMAI (708) and later by HAGIWARA himself (1258). Seeing that this gene is identical with TAKEZAKI and IMAI's **R**, we may adopt the latter symbol. Therefore HAGIWARA's **R** for scarlet color must be abolished, and IMAI's **A** may be substituted for it, for there are some reasons for considering the former gene as identical with the latter. One drawback in employing the symbol **P** for purple color, is the fact that MIYAKE & IMAI (725) had already worked with **p** for 'Kujakuba'. Hence the symbol **Pl** may stand for this gene.

F₂ segregation shows a more or less marked deficiency of cream flowers owing to the instability of the gene (**cm**). The seedling of this type is frequently characterized by one or more colored stripes on the green hypocotyle, the degree of which varies considerably in different individuals, but always disappear on the stem above the cotyledonous leaves.

As to the intensity of colors, MIYAKE & IMAI (725) found a monogenic difference between light and dark, the light color being dominant. Later IMAI (708) assumed two genes for color intensity, **L**₁ and **L**₂. **L**₁ produces normal colors, while **L**₂ dilutes colors in the presence of **L**₁; **l**₁ and **l**₂ stand for the production of dark colors. Thus:

L ₁ L ₂		light,
L ₁ l ₂		normal,
l ₁ L ₂	}	dark.
l ₁ l ₂		

The varieties of corolla pattern have been studied by HAGIWARA (904). The results of crossing are briefly summarized in TABLE XVII. His conclusions are as follows:

1) The white-margined corolla, called 'Fukurin' is dominant to the normal (confirming the results of IMAI, 631) and at the same time some 'Fukurin' are recessive to the normal. Two genes are assumed, **F** for 'Fukurin' pattern and **ih**¹⁾ inhibiting the activity of **F**. Hence:

Fih	}	normal-colored,
fih		
fih		
Fih		'Fukurin'.

2) The 'star' is another corolla variation in which only the central part of the corolla is colored, forming a star-pattern and the other part is white. HAGIWARA found that the 'star' is produced by a gene **St**²⁾ which is effective only in the homozygous condition of the genes **C** and **F**. Thus:

Cfst		totally colored,
CFst		'Fukurin',
CFSt		'Star'.

1) HAGIWARA symbolized this gene as **H**; this symbol, however, had been already used by IMAI (708) for a gene concerned in the heart-shaped leaf.

2) HAGIWARA's original designation is **S**, which had been used by IMAI (797) as the symbol of the gene causing total coloration in the flowers and stem.

The heterozygous condition of St (CCFFStst), however, causes an intermediate form of pattern, and the plants heterozygous for both St and C (CcFFStst or CcFfStst) have 'Fukurin' flowers, instead of the 'star'.

As to the spotted condition ('Kanoko'), TANAKA ('15) finds a monogenic ratio of 3 self-colored to 1 spotted in F_2 of some crosses. Later, IMAI (797) made a cross between a variety with white flowers and self-colored (dark purple) stem and one having flowers spotted with blue on a yellow ground color and stem spotted with dark purple. The F_1 plants had self-colored flowers and stem. In F_2 he obtained the following segregations:

Self-colored stem and flowers, 8: self-colored stem and white flowers, 4: spotted stem and flowers, 3: green stem and rarely spotted (on a yellow ground) flowers, 1.

These results were explained on the assumption that the parents had the genic constitutions, C(R)sSpY and c(R)Sspy respectively, in which

C and R: the complementary genes for flower color,

S: a gene causing total coloration in flowers (with C and R) and stem (by itself),

Sp: a gene causing partial coloration (spots) in flowers (with C and R) and stem (by itself),

Y: a gene for yellow flowers, its absence resulting in white.

The gene S is epistatic to the gene Sp, and is closely linked with the genes c and y, behaving just as if they were a single unit gene. The recessive sp gene gives rarely—in the presence of C—spotted flowers and green stem. Thus in F_2 we have:

- | | | | |
|------|-----------------|---------|---|
| I. | <u>CsYcSySp</u> | } | totally colored stem and flowers, |
| II. | <u>CsYcSyp</u> | | |
| III. | <u>CsYSp</u> | | spotted stem and flowers, |
| IV. | <u>CsYsp</u> | | green stem and rarely spotted flowers, |
| V. | <u>cSySp</u> | } | totally colored stem and white flowers. |
| VI. | <u>cSyp</u> | | |

The proportion of (I + II):III:IV:(V + VI) should be 8:3:1:4. Plants from Classes I and II proved to be heterozygous, segregating in F_2 again into four types in a similar proportion, while plants from Classes V and VI bred true to each type. Plants from Classes III and

IV were found to be homozygous for **C**, **s** and **Y** with one exceptional plant which gave some white-flowered and green-stemmed plants in F_3 . These new forms were regarded as having resulted through crossing over between either **CY** and **s**, or **Cs** and **Y**.

Another pattern of corolla, 'circular cloud' was described by IMAI (797). This pattern is characterized by linear development of pigments on the border of the corolla, and is governed by a single recessive gene **w**. This gene reacts in a peculiar way on the other genes **A** (for the scarlet color) and **F** (for the 'Fukurin' pattern), as shown by the following scheme of genes:

AFW		scarlet 'Fukurin',
AFw		scarlet 'circular cloud',
AfW		self-scarlet,
Afw		tinged scarlet,
aFW		dark red 'Fukurin',
aFw		dark red 'circular cloud',
afW		self-dark red,
afw		white.

Thus the combination of the two recessive genes, **w** and **f**, lightens the scarlet color produced by **A** and completely washes out the dark red color caused by **a**; the flowers, therefore, appear in pure white in spite of the presence of the basic color genes **C** and **R**.

The inheritance of flower-tube color was studied by MIYAKE & IMAI (725) and HAGIWARA (905). According to the latter author, the totally dark colored tube is a simple dominant to the light and to the partial respectively. The following two genes were assumed:

T₁: a gene for distributing colors all over the tube, regardless of the presence or absence of **C**; **t₁** causes partial coloration of the tube, only in the presence of **C**.

T₂: a gene for intensification to **T₁** or **t₁**; **t₂** has no effect.

Thus we have in the group of colored flowers:

CT₁T₂		totally colored tube,
Ct₁T₂		partially colored tube,
CT₁t₂		light colored tube.

Seed Coat Color. MIYAKE & IMAI (725) found a monogenic difference between black and brown, the black color being dominant. The gene was symbolized as **Br**. Later, MIYAZAWA (1057) made several crosses, the results of which are tabulated as follows. (See TABLE XVIII).

TABLE XVIII.—INHERITANCE OF SEED COLOR IN *Pharbitis Nil*.
(MIYAZAWA, 1957). (fl. = flower, s. = seed).

Contrasted characters	F ₁	F ₂
White fl., white s.—blue fl., brown s.	Light blue fl., black s.	9 blue fl., black s. : 3 blue fl., brown s. : 4 white fl., white s.
Blue fl., brown s.—white fl., ¹⁾ black s.	Blue fl., black s.	9 blue fl., black s. : 3 blue fl., brown s. : 3 white fl., black s. : 1 white fl., brown s.
White fl., white s.—scarlet fl., black s.	Blue fl., black s.	3 blue fl., black s. : 1 white fl., white s.
White fl., white s.—white fl., ¹⁾ black s.	Blue fl., black s.	9 blue fl., black s. : 3 white fl., black s. : 4 white fl., white s.
Black-striped s. (with variegated leaves)—non-striping (with green leaves)	Non-striping (green leaves)	3 normal (green leaves) : 1 striped (variegated leaves)

Colored seed coats have short hairs on the surface, while colorless ones are almost glabrous. The results of crossing were explained on the following genic assumption :

N : a gene for brown seed color, its absence resulting in white seed.

Br²⁾ : in presence of **N**, produces black seeds.

The gene **N** is absolutely linked with the chromogen gene for flower color **C**. Thus we get :

$\widehat{\text{CNRBr}}$ black seeds, colored flowers,
 $\widehat{\text{CNrBr}}$ black seeds, white flowers,
 $\widehat{\text{CNRbr}}$ brown seeds, colored flowers,
 $\widehat{\text{CNrbr}}$ brown seeds, white flowers,
 $\widehat{\text{cn(RBr)}}$ white seeds, white flowers.

Leaf Characters. In the Japanese morning glory, numerous abnormal types of the leaf are known which nearly always proved to behave as simple recessive to the normal, tri-lobed type. Several of these types are given below :

‘Maruba,’ i.e. Round leaf, the leaves being heart-shaped (**hh**).

1) Rather yellowish.

2) This gene is symbolized by MIYAZAWA as **K**. The symbol **k**, however, had been used for the dragon-fly leaf by IMAI (708). Hence we may substitute MIYAKE & IMAI's $\widehat{\text{Br}}$ for it.

TANAKA ('15), Sō & NISHIMURA (675), MIYAKE & IMAI (725, 817), IMAI (708, 1159), HAGIWARA (788, 903, 1258).

'Kujakuba,' slightly elongated heart-shaped leaf, resembling the leaf of the sweet potato (**pp**). The 'Kujakuba' type is invariably associated with a kind of double flowers, the so-called 'Kujakuzaki' (See p. 165). MIYAKE & IMAI (725), HAGIWARA (1258).

'Chirimenba,' i.e. Crapy leaf, having the leaf-surface considerably rugose and the margin rolled up (**tt**). This type is always associated with the candle-stick flower (CORRENS' *forma reduplicata*), in which the tube is transversely deeply folded twice on its lower part. The degree of folding varies considerably even in one and the same individual.

The normal-leaved but candle-stick flowered type behaves as a simple recessive in contrast to this type and also to the normal-flowered type. Hence **T** for normal flower with normal leaf, **t** for candle-stick flower with crapy leaf and **t'** for candle-stick flower with normal leaf constitute a triple allelomorphic series. HAGIWARA (625), IMAI (696).

'Tonboba,' i.e. Dragon-fly leaf. The leaves consist of two parts somewhat resembling expanded wings of a dragon-fly (**kk**). IMAI (708), HAGIWARA (788, 1258).

'Rangikuba', with a very irregularly and deeply lobed leaf (**ii**). In this strain, the corolla is usually twisted and consists of numerous petals (called 'Rangikuzaki'). The cotyledons are frequently split in an irregular manner. These features are due to the pleiotropic effects of a single **i** gene. HAGIWARA (788, 1258), IMAI (708, 1159, 1272).

'Uzu', i.e. leaf characterized by whirled overlapping leaf-bases, being thick, and frequently dark green with a glazed surface (**dd** according to IMAI or **uu** according to HAGIWARA). The plants are also characterized by thick and brittle stems, short internodes, somewhat contracted flowers and also smaller seeds than those of the normal plant. HAGIWARA (625, 696, 1147), IMAI (631, 708, 1159).

There is another 'Uzu' type, which is an intermediate form between the normal and the true 'Uzu' types (**dhdh** according to IMAI, or **usus** according to HAGIWARA). In this type the leaves are slightly smaller and have a polished, uneven surface. HAGIWARA (1147), IMAI (1159).

Concerning these 'Uzu' types, IMAI assumed the following scheme of genes:

<u>DDh</u>		normal,
<u>Ddh</u>		'semi-Uzu',
<u>dDh</u>	}	 'Uzu'.
<u>ddh</u>		

'Tatutaba', i.e. 'Maple' leaf. The leaves have five lobes, somewhat resembling the maple leaf in general appearance (**mm**). This type always has split corolla. TOYAMA ('16), IMAI (708, 1159), HAGIWARA (1258).

'Yanagiba', i.e. 'Willow' leaf, the leaves being narrow and slenderly elongated like those of the willow. The corolla of the 'willow' plants always split into five narrow petals, the splitting reaching almost to the base of the corolla tube and giving a more slender appearance than the split corollas of other strains, such as the 'maple' and the 'Sasa'. These features are the multiple representations of a single recessive gene **m'**. **M**, **m** (for the 'maple' leaf) and **m'** were found to constitute a series of triple allelomorphs, the order of dominancy being **M-m-m'**. The 'willow' plants sometimes have 'maple' branches as vegetative sports, and more frequently give a few 'maple' plants in the segregating strains for the 'willow' leaf. These reversions, both vegetative and gametic, are due to the transformation of the gene **m'** to **m**. IMAI (1159, 1272).

'Kakeba', i.e. Defective leaf, an irregularly lobed form. The plants of this strain show this peculiarity in a few leaves only. The defective parts of the leaves are often accompanied by a faint variegation. Sometimes there occur false normals all of which are perfectly normal leaves, but are genotypically of the defective type, giving rise in their self propagated progenies to many defectives and a few false normals. IMAI (1159).

'Sasa', in which the leaves are thin and have sharp apices, giving an impression of delicacy (sasa). This type is always associated with split corollas. The sa gene is unstable, the plants frequently giving the vegetative as well as the individual sports. IMAI (1159).

'Utikomi', i.e. Pitted or rolled leaf, the leaf-surface being irregularly pitted and the margin rolling up slightly. Two kinds of pitted leaves were genetically distinguished by IMAI (1159) (uvuv and usus, the gene uv being identical with the **d** of HAGIWARA, 625). The plants heterozygous for these two genes, when selfed, give rise to rolleds and normals in a ratio of 11:5, indicating that the presence of more than two doses of either or both of the recessive genes results in the rolled leaves. The double recessive condition of the genes results in a strongly rolled leaf.

'Suhama', a form with the midrib of the lamina very short (susu). This characteristic may appear even in the cotyledonous leaves. The corolla of this type is large, and consists of more than five petals. The so-called 'Chidori' is a normal form carrying the 'Suhama' character, and 'Semiba' is a dragon-fly leaf carrying the same character. The 'Suhama' type of the heart leaf is called 'Hoshu'. IMAI (1159).

'Hanaba', i.e. Nose-leaf, in which the margins of the wing lobes are round (nsns)¹⁾. IMAI (1159).

'Rimpū', a form of leaf, sinuated with wedge-shaped petiole expanding toward the base of the lamina, so that there is no sharp line of demarcation between lamina and petiole. This peculiarity may be seen even in the cotyledonous leaves. This type behaves as a character dominant over the normal, the only dominant case among the abnormal leaf characters hitherto studied (BwBw). Sō & NISHIMURA (675), IMAI (1159).

'Nantenba', the leaves having the margins rolled back and reminding of a leaf of *Nandina* (nana). The gene na manifests its effects on all parts of the plant. HAGIWARA (1258).

'Variegated leaf' (vv). HAGIWARA (625, 696, 788), IMAI (631, 708, 797), MIYAKE & IMAI (725, 817), MIYAZAWA (1057), TAKEZAKI ('16).

Besides the common variegation, a peculiar type, called 'Gejigeji-variegation' (ghost-variegation) is known, resembling somewhat the faint variegation of the defective leaves. The 'Gejigeji' type is recessive to the common variegation in inheritance (vgvg). Relations between these two types were found to be as follows (IMAI, 1159):

V(Vg) normal,
vVg common-variegated,
vvg ghost-variegated.

'Yellow (chlorina) leaf' (g₁g₁)²⁾. TAKEZAKI ('16), IMAI (708), MIYAKE & IMAI (817), MIYAZAWA (568, 569, 726).

'Albino', which are characterized by the failure of chlorophyll development but having a few whitish plastids (g₂g₂). The seedlings perish within a short time after germination. YASUI (749), IMAI (1159).

1) IMAI's original symbol for this gene is n; this symbol, however, had been used by MIYAZAWA (1057) as the recessive gene for brown seed coat color. Hence we may substitute ns for IMAI's n.

2) The symbols, g₁ and g₂, are adopted by Miss. YASUI, who obtained a digenic segregation indicating the following scheme of genes: G₁G₂=green, g₁G₂=chlorina, G₁g₂ and g₁g₂=albino. (Unpublished data).

Doubleness of Flowers. Several different sorts of doubling have been found and genetically studied in *Ph. Nil.* All of them differ in a single gene from the normal type, the latter being dominant.

'Common double flower', a form characterized with petalody of pollen-sacs (d_1d_1). MIYAKE & IMAI (817).

'Kujakuzaki', another form characterized by petalody of filaments, and is always accompanied by the 'Kujakuba' (pp). MIYAKE & IMAI (725). HAGIWARA (1258).

In these two types of doubling, the female organs are practically fertile, and when the doubleness is not extreme, the well-formed anthers contain plenty of pollen.

'Botanzaki', a form characterized by proliferation ($btbt$). There are neither male nor female organs developed. Hence the plants can be raised only from the heterozygotes. MIYAKE & IMAI (817).

'Shishizaki', a form characterized by irregular paracorollar excrescences, called 'feathering' ($sisi$). This has the petals more or less curled up, and represents very conspicuous variations in the degree of feathering. In its extreme form, the corolla is divided into five slender, thread-like, branched petals. The 'Shishi' type is always accompanied by rolled-leaf margins. The plants have both male and female organs, but are sterile in most cases. So & NISHIMURA (675); MIYAKE & IMAI (817).

Pubescence on the Stem. IMAI (1029) made a cross of smooth $\times$ pubescent. The F_1 plants were pubescent and in F_2 pubescent and glabrous plants appeared in a ratio of 13:3. The results were explained on the assumption of two genes: Hs for smooth stem, its absence standing for pubescent stem; Hh inhibiting the effect of hs , its absence being non-effective. Thus:

$$\left. \begin{array}{l} \underline{HsHh} \\ \underline{hsHh} \\ \underline{hshh} \end{array} \right\} \dots \dots \dots \text{pubescent,}$$

$$\underline{Hshh} \dots \dots \dots \text{smooth.}$$

Other Stem Characters. According to HAGIWARA (1146), a fasciated form is a double recessive character owing to the co-operation of the two recessive genes p and f , the former alone causing the slightly elongated heart leaf called 'Kujakuba'.

A dwarf type, called 'Dwarf-Uzu' was described by HAGIWARA (1147). In this type the leaf is normal-shaped but thick, the internodes are short, and the stem is not twining. Its foliage color is darker and

the flower is smaller than the normal. The difference between the 'Dwarf-Uzu' and the normal is monogenic, the dwarf type being recessive (udud). This dwarf type crossed with the 'Uzu' type (uu) gives a reversionary form which can not be distinguished from the normal

TABLE XIX.—LINKAGE IN *Pharbitis Nil*.

Linked genes	Linked characters	c.o. %	Authors
1) <u>uv</u> — <u>v</u>	Pitted leaf—variegated leaf	13-20	{ IMAI (631, 797, 1159) HAGIWARA (625, 788, 903) IMA I (1159)
<u>v</u> — <u>Bw</u>	Variegated leaf—'Rimpū '	33	
<u>uv</u> — <u>Bw</u>	Pitted leaf—'Rimpū '	32	
<u>us</u> — <u>sa</u>	Pitted leaf—'Sasa ' leaf	5 ?	
2) <u>h</u> — <u>si</u>	Heart-shaped leaf—'Shishi ' flower	1	{ IMAI (797) MIYAKE & IMAI (817, 1290) HAGIWARA (788, 903)
? <u>h</u> — <u>v</u>	Heart-shaped leaf—variegated leaf	42	
According to IMAI, however, there exists no connection between these two genes.			
? <u>h</u> — <u>uv</u>	Heart-shaped leaf—variegated leaf	43	{ HAGIWARA (788, 903) IMA I (1159)
<u>h</u> — <u>dh</u>	Heart-shaped leaf—' semi-Uzu '	21	
<u>dh</u> — <u>t</u>	' Semi-Uzu '—candle-stick flower	50	
<u>si</u> — <u>dh</u>	' Shishi ' flower—' semi-Uzu '	17	
<u>t</u> — <u>h</u>	Candle-stick flower—heart-shaped leaf	40	
3) <u>g</u> — <u>A</u>	Yellow leaf—scarlet flower	1	{ MIYAZAWA (568, 569) IMA I (797, 1159, 1271)
4) <u>S</u> — <u>Y</u>	Self-colored flower—yellow ground color		
<u>S</u> — <u>C</u>	Self-colored flower—colored flower		{ IMA I (797)
<u>C</u> — <u>Y</u>	Colored flower—yellow ground color		
These three genes, <u>S</u> , <u>C</u> and <u>Y</u> are very closely linked. IMAI suggests from his experiments that there occurs 1% crossing over between <u>CY</u> and <u>S</u> or between <u>CS</u> and <u>Y</u> .			
<u>C</u> — <u>L</u> ₂	Colored flower—light colored flower	1.4	{ IMAI (797) HAGIWARA (906)
<u>C</u> — <u>k</u>	Colored flower—dragon-fly leaf	33	
<u>d</u> — <u>F</u>	' Uzu '—' Fukurin ' flower	1	{ IMAI (631, 797, 1271) HAGIWARA (906)
<u>d</u> — <u>L</u> ₂	' Uzu '—light colored flower	25-33	
5) <u>T</u> ₁ — <u>T</u> ₂	Totally colored tube—dark colored tube	20	{ HAGIWARA (905)
<u>B</u> — <u>T</u> ₁	Blue flower—totally colored tube	22	
<u>Pl</u> — <u>T</u> ₁	Purple flower—totally colored tube	22	
<u>Pl</u> — <u>T</u> ₂	Purple flower—dark colored tube	1.4	

plant, and shows segregation in F_2 into the normal, 'Uzu' and dwarf plants in a ratio of 9:3:4. The double recessive plants are smallest, being 2 or 3 inches in height.

Another type of dwarfishness has been observed by IMAI (1159), in which the flowers are normal-sized and the leaves are not thick. This type behaves as a recessive to the normal. The same author also reports that the bush-growth habit is a recessive to the normal.

Linkage Relations.^D Considerable attention has been paid to the interrelations between a number of genes in the Japanese morning glory. A short summary of linked genes is given above in a tabular form (TABLE XIX).

Pharbitis purpurea

Color of Flower and Stem. BARKER (482) identifies the following several genes for flower color: **C** for chromogen, **R** for oxydase, **B** for blue, **X** and **I** for intensification of colors. The color varieties may be represented as:

CRBXI		dark purple,
CRBXi		dark blue,
CRbXI		magenta,
CRbXi		mauve,
CRBxi		light blue,
CRbxi		pink

The combinations lacking either or both **C** or **R** result in white. There exist various intermediate heterozygous forms. The author also states that flaking is a dominant character.

According to IMAI (708, 917), an intimate relation exists between flower color and stem color. The red color in the stem is associated with dark-colored flowers, the dilute red stem with faint-colored flowers and the green stem with white flowers. A cross between green with white flowers and red with dark red flowers gave in F_2 a ratio of 9 red: 3 dilute red: 4 green concerning stem color. Two genes were assumed, **R** for red and **S** for its intensification. Among the red-stemmed group several flower colors were obtained, viz. dark red, red, pale red and patched; similarly the pale red-stemmed group contained dark pink, pink, tinged white and white flowers. Patching in the rays of the corolla is assumed to be due to the absence of a gene **U**. Still another

1) The haploid chromosome number in *Parbitis Nil* is 12-14. (Vide TISCHLER, *loc. cit.*)
P.S. According to the latest determination of Miss. YASUI in 11 strains of *Ph. Nil*, the haploid number is 15.

gene **D** is responsible for the dilution of color. Several intermediate heterozygous forms are caused by the genes **R** and **U**. Thus:

RSUD	red (RRUU) or pale red (RRUu , RrUU , RrUu)	} Red stem,
RSud	dark red (RRUU), red (RrUU) or pale red (RRUu , RrUu)	
RSuD }	 patched (RR , Rr)	
RSud }		
RsUD	pink (RRUU , RrUU) or tinged white (RRUu , RrUu)	} Pale red stem.
RsUd	dard pink (RRUU), pink (RrUU) or tinged white (RRUu , RrUu)	
RsuD }	 white	
Rsud }		
r(RSUD)	white	Green stem.

The data showed that there exists a partial linkage between **S** and **D**, giving a gametic ratio of 1 : 2.5 : 2.5 : 1.

Other Characters. In the same papers, BARKER and IMAI report that there is a monogenic difference between black and yellow-brown in the seed coat and also between double feathered flowers and normal flowers, the first mentioned forms being dominant in both cases.

Phaseolus chrysanthos

Seed Coat Color and Pattern. A number of crosses have been made by TAKAHASHI & FUKUYAMA (513) to study the inheritance of seed coat color in the Adzuki-bean. The results obtained (See TABLE XX) led the authors to the assumption of the following genes:

R: a gene for red; its absence (**r**) results in white.

H: a gene inhibiting the effect of **R**.

F: conjointly with **R**, gives buff (grayish yellow).

G: a gene for green; its manifestation does not concern **R**.

C: acting together with **R** and **M**—a gene for mottling—gives black.

Interrelations of these genes may be represented as:

RHCM(FG) blue black,

RhCM(FG) black,

RHcm(F)G }

r(HCMF)G } green,

RHcmFg deep buff,

RHcmfg buff,

Rhcm(F)g red,

r(HCMF)g white.

TABLE XX.—INHERITANCE OF SEED COAT COLOR AND PATTERN IN
Phaseolus chrysanthos, THE ADZUKI-BEAN. A summary of
 the results obtained by TAKAHASHI & FUKUYAMA (513).

Contrasted colors	F ₁	F ₂	Genes involved
Red—white	Red	3 red : 1 white	R H C
Buff—white	Buff	9 buff : 3 red : 4 white	
Green—red	Pale green	9 green : 3 buff : 4 red	
Green—white	Pale green	39 green : 12 red : 9 buff : 4 white	
Deep buff—buff	Deep buff	3 deep buff : 1 buff	F
Deep buff—white	Deep buff	27 deep buff : 9 buff : 12 red : 16 white	
Black mottled red—red	Black m. red	3 black m. red : 1 red	M
Black mottled red—white	Black m. red	9 black m. red : 3 red : 4 white	
Black mottled red—green	Black m. green	27 black m. green : 9 black m. buff : 9 green : 12 black m. red : 3 buff : 4 red	Z
Black mottled buff—red	Black m. buff	9 black m. buff : 3 black m. red : 3 buff : 4 red	
Black mottled buff—white	Black m. buff	27 black m. buff : 9 black m. red : 9 buff : 3 red : 16 white	
Black mottled green—red	Black m. green	27 black m. green : 9 black m. buff : 9 green : 12 black m. red : 3 buff : 4 red	
Black mottled green—white	Black m. green	81 black m. green : 27 black m. buff : 75 green : 36 black m. red : 9 buff : 12 red : 16 white	
Red-eyed white—red	Red	3 red : 1 red-eyed white	
Red-eyed white—white	Red	9 red : 3 red-eyed white : 4 white	
Red-eyed white—black mottled red	Black m. red	9 black m. red : 3 red : 3 black m. red-eyed white : 1 red-eyed white	
Red-eyed white—black mottled green	Black m. green	Black m. green, black m. buff, black m. red-eyed green, black m. red-eyed white, green, buff, black m. red, black m. red-eyed white, red, red-eyed white = tetrahybrid (?)	
Black—red	Black	3 black : 1 red	C (RMC × Rmc) (RMC × rmc) (RMC × RMc)
Black—white	Black	9 black : 3 red : 4 white	
Black—black mottled red	Black	3 black : 1 black m. red	
Black—black m. buff	Blue black	9 blue black : 3 black : 3 black m. buff : 1 black m. red	
Black—deep buff	Blue black	36 blue black : 12 black : 9 deep buff : 3 buff : 4 red	(RhMCf × RHmcF)
Black—red-eyed white	Black	9 black : 3 red : 3 black m. red-eyed white : 1 red-eyed white	
Black—green	Blue black	108 blue black : 36 black m. green : 36 black : 12 black m. red : 36 green : 12 buff : 16 red	(RhGMC × RHGmc)

As to color pattern, the same authors established the following genes:

M: a gene for black mottling, having no effect without **R**.

Z: a gene causing total coloration, its absence (**z**) resulting in the 'eye' pattern.

Thus:

RMZ black-mottled red,

RmZ red,

RMz black-mottled red 'eyed' white (that is, red 'eyed' white with black mottling on the colored part),

Rmz red 'eyed' white.

In most cases, the gene pairs **C—c** and **M—m** are completely coupled together; thus, for example, black (**RM $\widehat{C}$**) $\times$ red (**Rm $\widehat{c}$**) gives in F_2 3 black to 1 white; black (**Rh $\widehat{M}$ $\widehat{C}$**) $\times$ black-mottled buff (**RH $\widehat{M}$ $\widehat{c}$**) yields in F_2 blue black (**RH $\widehat{M}$ $\widehat{C}$**), black (**Rh $\widehat{M}$ $\widehat{C}$**), black-mottled buff (**RH $\widehat{M}$ $\widehat{c}$**) and black-mottled red (**Rh $\widehat{M}$ $\widehat{c}$**) in the ordinary dihybrid ratio. A few cases, however, were found to be exceptions to this rule. The cross, black (**Rhg $\widehat{M}$ $\widehat{C}$**) $\times$ green (**RHG $\widehat{m}$ $\widehat{c}$**), gave in F_2 the tetrahybrid segregation, indicating that **M** and **C** were in this case independently inherited. It was assumed that the presence of the gene **G** prevents these two genes from making the coupling. The cross, black (**RM $\widehat{C}$ $\widehat{Z}$**) $\times$ red-eyed white (**Rmc $\widehat{z}$**) gave in F_2 black (**RM $\widehat{C}$ $\widehat{Z}$**), red (**Rmc $\widehat{Z}$**), black-mottled red-eyed white—instead of black-eyed white (**RM $\widehat{C}$ $\widehat{z}$**)—and red-eyed white (**Rm $\widehat{c}$ $\widehat{Z}$**) in a ratio of 9:3:3:1. The results were explained on the assumption that the absence of **Z** inhibits the effect of **C**.

A part of these results was confirmed by BLAKESLEE & AVERY (483), KAKIZAKI (919, 1035) and MIYAKE, IMAI & TABUCHI (1198).

Stem Color. TAKAHASHI & FUKUYAMA (513) and later KAKIZAKI (919, 1035) found that the deep purple color in the stem, leaf-stalk, calyx and other parts is due to two genes **P** and **I**, the former causing the purple color and the latter intensifying it. Later, MIYAKE *et al* (1198) obtained other results; purple $\times$ green gave in F_2 a ratio of 9:7, indicating that the purple color depends upon the existence of two complementary genes, **C** and **R**.

Thus we get:

CRI deep purple,

CRi purple,

Other combinations . . . green.

Pod Color. The ripe pod-color of the Adzuki-bean is either blackish brown, brown or white (pale yellow). As regards the inheritance of the pod-color, the following results were obtained by TAKAHASHI & FUKUYAMA (513).

- 1) Blackish brown $\times$ brown $\rightarrow F_1$, blackish brown $\rightarrow F_2$, 3 : 1.
- 2) Blackish brown $\times$ white $\rightarrow F_1$, blackish brown $\rightarrow F_2$, 9 blackish brown : 6 brown : 1 white.
- 3) Brown $\times$ white $\rightarrow F_1$, brown.

The genic scheme was given as :

B_1B_2 blackish brown,
 B_1b_2 }
 b_1B_2 } brown,
 b_1b_2 white,

Similar results were obtained later by KAKIZAKI (919, 1035).

Form of the Hair. The hairs covering the stem, leaves, bracts and other parts may have either round or sharp apex. TAKAHASHI & FUKUYAMA (513) found that the difference is monogenic, the sharp hair being dominant.

Form of the Leaf. Nearly all varieties of the Adzuki-bean have round broad leaves, while a few varieties are characterized by narrow leaves with sharp apex. The difference was found to be monogenic by TAKAHASHI & FUKUYAMA (513), the narrow leaf being incompletely dominant.

*Linkage Relations.*¹⁾ TAKAHASHI & FUKUYAMA (513) found a close linkage between **M**, a gene for black-mottled seed, and **P**, a gene for purple stem, with 0.6% crossing over. According to KAKIZAKI (919, 1035), however, the green or purple stem is always (!) correlated with non-spotted or spotted seed coat respectively, and the deep purple or light purple stem is always accompanied with blackish brown or brown pod respectively.

Later, MIYAKE *et al* (1198), from red-stemmed black seeds $\times$ green-stemmed red-eyed white seeds, found that all colored stems gave only self-black seeds, while all green stems gave either self-red, black-mottled red-eyed white, or red-eyed white.

From these results it is certain that there is absolute coupling between (i) **C** and **M**, (ii) **R** and **Z**, and (iii) **I** and **B₁** (or **B₂**).

1) Mr. J. KAWAKAMI kindly writes me that the haploid chromosome number in this plant is 11.

Phaseolus multiflorus

Several investigators have studied the inheritance of seed coat color and pattern in *Ph. multiflorus*. Some earlier observations on the subject were made by TSCHERMAK (268) and REINKE (418). According to the latter author, the absence of color, white, is dominant to the coloring. But TSCHERMAK suggested that colored testa is dominant to white, and also marbling to self-coloring.

TJEBBES & KOOIMAN (660) made a species-cross between *Ph. multiflorus* with marbled seeds (black on a violet ground color) and *Ph. vulgaris* with white seeds, and obtained in F_2 a monogenic segregation, marbling being dominant.

SIRKS (959), using several varieties of *Ph. multiflorus*, recognized the following pairs of colors or patterns as monogenically different from each other, the first given members being dominant:

- 1) Dark violet marbled (with black)—light violet marbled.
- 2) Light violet spotted (with black)—light violet marbled.
- 3) Black—light violet marbled. (Some blacks gave a segregation of 12 black : 3 light violet marbled : 4 white).
- 4) Light violet marbled—brown marbled (papillon pattern).
- 5) Brown marbled—gray-white marbled.

It was also found that light violet marbled plants threw some white plants in a proportion of 168 : 23.

TJEBBES (1315) made a cross, white (Weisse Langschotige) $\times$ dark violet mottled, and obtained the latter type in F_1 . F_2 progeny consisted of three groups, dark mottling, shaded ('abgestuft') mottling (mottling with deep black on a gray pattern) and white in a ratio of 1 : 2 : 1. The results obtained in later generations showed that these three types form a series of multiple allelomorphs. The scheme of genes is thus:

$\begin{array}{l} \text{AdAd} \\ \text{AdAu} \\ \text{AuAu} \\ \text{Ad a} \\ \text{Au a} \\ \text{a a} \end{array}$	$\left. \begin{array}{l} \text{ } \\ \text{ } \\ \text{ } \\ \text{ } \\ \text{ } \end{array} \right\}$	$\begin{array}{l} \dots\dots\dots \text{dark mottling,} \\ \dots\dots\dots \text{shaded mottling,} \\ \dots\dots\dots \text{white.} \end{array}$
--	---	--

It was also found that the homozygote of Ad is almost entirely, and that of Au in high degree self-sterile. In another cross, white (Chilensische Weisse Feuerbohne) $\times$ mottled, the same author found that the white

parent carried a dominant gene **S** which acts only in the presence of **Ad**. **SSAd(Ad)** is entirely striped, while **SsAd(Ad)** shows normal mottling and partial striping. **S** is also epistatic to a gene **B** which stands for the total pigmentation.

Phaseolus vulgaris

Seed Coat Color and Pattern. The inheritance of the seed coat color in common garden beans which has received most attention in this genus is much complicated. The reason is not in the great variation of this character, but rather in the confusion of the mode of denominating the genes and also colors, as pointed out by KRISTOFFERSON (1179), who says: "Different writers use one and the same symbol for different factors, and others use different symbols for one and the same factor. . . . Furthermore, the identifying of the colour nuance referred to is very difficult. Papers on this subject are written in at least six different languages, and writers of the same language often use different denominations for the same nuance." For these reasons, it is not possible to give genic relations under one scheme to cover all facts obtained by several experimentors. Mention will be made, therefore, simply of the results obtained by various authors.

LOCK (63) gives a preliminary account on a cross of a dark purple-seeded bean with a dark yellow-seeded bean. The dark purple color was dominant in F_1 . The F_2 progeny consisted of two groups, purple and yellow, both containing various shades of color.

TSCHERMAK (44, 268, etc.) from his results (See TABLE XXI) suggests the existence of three color-genes, **A** for the basic gene, **B** for violet and **C** changing violet to black. According to him, the gene **B** may be analyzed into two components, **B₁** for violet and **B₂** for red. **B₁** is epistatic to **B₂**. Thus we get:

AB₁(B₂)C	}	 black,
A(B₁)B₂C		
AB₁(B₂)c		violet,
Ab₁B₂c		red,
Ab₁b₂(C)		yellowish brown.

The most hypostatic color is shown by his yellowish brown 'Non plus ultra.' The absence of **A** makes the testa white.

SHULL (83, 100) reports that light greenish-yellow ('Long yellow six weeks') and yellow-brown ('Non plus ultra') are hypostatic to purple-black ('Prolific black wax'). Crosses between white ('White flageolet')

and yellow or yellow-brown gave purple-mottled testa in F_1 , and in F_2 purple (mottled and self-color), brown or yellow (mottled and self-color) and white in a ratio of 9 : 3 : 4. Two genes are postulated, **P** for the pigment and **B**, modifier which changes the pigment to purple.

Later, EMERSON (113) showed that light yellow is hypostatic to yellow-brown, dark brown to yellow-brown, black to dark brown and yellow-brown to red. He postulates the following four genes :

O : a gene changing yellow to yellow-brown.

D : a gene for dark brown ; epistatic to **O**.

B : a gene changing dark brown to black.

R : a gene for red ; hypostatic to **O**.

KAJANUS (349) gives some results of spontaneous crossing in which the monogenic dominance of brown-yellow over citron-yellow was shown.

LUNDBERG & ÅKERMAN (503), from a spontaneous hybrid, assumed two genes, **G** for yellowish brown and **C** for chocolate, their combination resulting in dark brown, and the absence of both in yellowish white. All these varieties contain the basic gene, the absence of which is to result in white.

SHAW & NORTON (582), using a number of color varieties of garden beans, identified several color genes (See TABLE XXII). They classified the seed colors into two series, viz., a yellow black series and a red one. Besides the basic gene **P** which gives by itself buff or ecru color and the absence of which results in white, the following genes have been assumed.

a) Yellow-black series :

M : a basic gene for yellow-black series.

H : a gene for light brown or olive brown.

C : a gene for yellow.

F : a gene for coffee brown.

G : a gene for black.

G is epistatic to **H**, **C** and **F**, but the interrelation of the genes for this series has not been quite determined.

b) Red series :

M' : a basic gene for red series.

D : a gene for light red.

E : a gene for dark red.

E is epistatic to **D**.

The genes **M** and **M'**, according to their opinion, are enzymes which are necessary for the production of pigments. When these genes are

absent, the color will be buff or ecru even if the basic gene **P** and other genes of the respective series are present. The authors have assumed the existence of still another gene for black in an exceptional variety, 'Crease-black.'

The same authors also found certain correlations between seed- and flower-colors. All white (or eyed) beans are accompanied by white flowers; all black (or black-mottled) beans by dark pink flowers. Seeds of various yellow and brown colors (and mottled beans other than black-mottled beans) are usually accompanied by light pink flowers.

TJEBBES & KOOIMAN (660, 848) also explained their results on the assumption of several genes as follows:

F: a basic gene for pigmentation.

B: a gene for yellowish brown.

S: a gene for violet stripes.

Bl: a gene for blue.

Z: a gene for black.

The genes **B** and **S** show absolute repulsion in segregation. The genes **Bl** and **S** have certain pleiotropic effects on other parts of plants, especially on the color of the stripes in the pods and of the flowers, thus:

SBl blue stripes in the pods, violet flowers,

sBl blue stripes in the pods, lilac flowers,

Sbl bright red stripes in the pods, lilac flowers,

sbl pale stripes in the pods, white flowers.

Thus in the absence of **S**, the gene **Bl** only shows its effect on the pods.

In other papers (716, 1044), KOOIMAN assumes the following several genes:

A: a basic gene for pigmentation; by itself, having no effect.

B: acting together with **A**, gives a lemon-yellow color, a small ring around the navel remaining uncolored; heterozygous **B** causes inconstant marbling (See p. 177).

C: conjointly with **A**, gives a brownish color.

D: acting together with **A**, but in the absence of both **B** and **C**, gives a brown color of the navel ring only, and an almost invisible gray dotting on the rest of the seed coat.

E: a gene intensifying the brown colors.

F: a gene giving a gray or violet tinge upon the brown colors.

TJEBBES & KOOIMAN (966) showed certain connection between these genes and colors of the flowers. The gene, **F**, produces—in co-operation of **AB**, **AC** or **AD**—pale lilac flowers.

SIRKS (741, 959) explains his results (See TABLE XXIII) on the assumption of the following genes :

P: a basic gene for pigmentation ; by itself produces a buff color.

G: a gene for yellowish brown.

L: a gene for dark brown.

V: a gene for violet ; hypostatic to **L**.

Gr: a gene giving a gray glow in addition to the other colors.

B: a gene changing violet into blue.

S: a gene locally restricting the blue, violet and gray colors, and thus making stripes.

KRISTOFFERSON (1198), working at an Old Swedish variety of asparagus bean, 'Steninge Hybrid,' identifies still another gene **K** which causes a black color and the absence of which results in a steel color.

As regards mottling (marbling), it has been pointed out by several investigators that there are two kinds of mottled beans, viz., those with :

1) Constant mottling, which when crossed with a self-colored variety proves to be dominant, giving segregation of 3 mottled : 1 self-colored in F_2 . Experimentors :—TSCHERMAK, EMERSON, TJEBBES & KOOIMAN and others.

2) Inconstant mottling, which results from some crosses between self-colored and white plants or between two self-colored strains, and proves to be always heterozygous, showing segregation in a ratio of 1 mottled : 1 self-colored or white. Experimentors ;—TSCHERMAK SHAW & NORTON, SHULL, EMERSON, KOOIMAN, KRISTOFFERSON and others.

As to the interpretation of the existence of these two sorts of mottling, we have several different hypotheses, as may be seen in the following accounts :

α . TSCHERMAK's hypothesis. The constant mottling is due to a single dominant gene, while the inconstant mottling is due to the heterozygous condition of another mottling gene which was present in a state of latency in the uniformly colored race.

β . SHULL's hypothesis. SHULL also regarded the inconstant mottling as due to the heterozygous condition of a definite gene, **M**, but believed that the gene was latent in the white parent. Beans homozygous for **M** (**MM** or **mm**) are self-colored. Constant mottling was regarded as caused by another dominant gene.

γ . EMERSON's hypothesis. EMERSON also suggests a scheme by postulating two genes for mottling, **M** for the constant mottling, and **X** for the inconstant mottling which is visible only in the heterozygous

condition. The relation between **M** and **X** is not settled, but the results he obtained can be explained on the basis of this scheme. These genes are effective only in the presence of **P**, the basic gene for pigmentation. Thus the scheme of the genes may be represented as :

PMX ???

PMx mottled (for all the mottled races),

PmX self-colored (**XX**) or mottled (**Xx**) (for Schwarze Neger or Hundert für Eine),

Pmx self-colored (for Scarlet, Flageolet, Stringless Green, Ultra, Challenge, Black, Yellow Six Weeks, etc.),

pMX white (for ?),

pMx white (for Davis, Marrow and Navy),

pmX white (for Wachsschwert, White Flageolet and Navy),

pmx white (for Chevrier and Jones).

EMERSON also proposes another hypothesis suggested by SPILLMAN in his *Vigna* experiments (see p. 288) that mottling is due to the co-operation of two genes, **Y** and **Z**, which are absolutely coupled together in constant mottled forms. The cross between two self-colored races, $\widehat{YzYz}$ and $\widehat{yZyZ}$, results in the mottled F_1 ($\widehat{YzyZ}$). The segregation of F_2 will be 1 $\widehat{YzYz}$: 1 $\widehat{yZyZ}$: 2 $\widehat{YzyZ}$, thus the ratio becomes 2 self-colored : 2 mottled. EMERSON himself inclines to the latter, rather than the former, hypothesis. KRISTOFFERSON also adopts this coupled-gene hypothesis.

5. KOOIMAN's hypothesis. KOOIMAN also postulates two genes for mottling, **M**, the gene for mottling which breeds true, and **B**, the gene which produces mottling in the heterozygous condition. The gene **B** also gives—in the presence of the basic gene **A**—a colored testa, with the exception of a small ring around the navel. Thus the heterozygous mottled beans (**AABb**) give self-colored, mottled and white beans in a ratio of 1 : 2 : 1. Besides this type of segregation, he has observed another type, which gave 8 mottled : 7 self-colored : 1 white. This segregation can be explained on the assumption that the mottled parent has the constitution, **AABbCc**, in which the gene **C** causes total coloration in the presence of **A**. Thus **AABbCc** gives :

1 AABBCC	} self-colored,
2 AABBCc	
1 AAbbCC	
1 AABbCc	
2 AAbbCc	

2	AABbCC	}	 mottled,
4	AABbCc		
2	AABbcc		
1	AAbbcc		 white.

Whether or not any of the hypotheses above given covers the fact is still unsettled.

Striping of the testa is also another character, in which the colors are restricted to long stripes. Striped beans are dominant to non-striped, and give the monogenic segregation in F_2 . The gene is designated as **S** by most experimentors, e.g., TSCHERMAK, TJEBBES & KOOLMAN, SIRKS. According to TSCHERMAK, the gene **S** is hypostatic to the mottling gene **B**.

The eyed-pattern has been studied by TSCHERMAK, EMERSON, KOOLMAN, SAX (1074), SAX & MCPHAE (1075) and others. TSCHERMAK, from his experimental results, suggests the existence of two genes concerning distribution of colors, Z_1 and Z_2 . The gene Z_1 causes the extension of the pigment over the whole seed coat; while its absence results in partially pigmented beans. In the partially pigmented beans (z_1z_1), there are three groups as to the pigmented area which is affected by the other gene Z_2 , viz.,

- 1) $z_1z_1Z_2Z_2$ seeds having 1/2 or more of the whole testa pigmented within sharp limits (his 'Group 2'),
- 2) $z_1z_1Z_2z_2$ seeds having 1/2 or less pigmented area without sharp limits (his 'Group 1'),
- 3) $z_1z_1z_2z_2$ seeds having the pigmented area confined to a very small spot around the navel (his 'Group 3').

EMERSON designates the gene for the total coloration as **T**. This gene has no visible effect without **P**, the basic gene for pigmentation. Thus its presence in a latent state is possible in white beans. Hence **PT** is totally pigmented, **Pt** eyed, **pT** and **pt** white.

SAX & MCPHAE and SAX have obtained some rather unusual results from the cross between two types of eyed beans: 'Old Fashioned Yellow Eye' $\times$ 'Improved Yellow Eye' (See TABLE XXIV). In this case a single gene was found to be concerned. The heterozygous condition for this gene, however, produces pigmented area wider than double that of the parents.

Growth Habit. EMERSON (438), studying crosses between a tall pole (showing indeterminate growth) bean and a short bush (showing deter-

minate growth) bean, or a short pole bean and a tall bush bean, found that there were at least three genes governing the habit of the plant. They are:

A—a: indeterminate vs. determinate growth,

B—b: long vs. short internodes,

C—c: many vs. few internodes.

These characters can be transmitted independently of one another, but they necessarily influence one another during the development of the plant. Thus as regards the number of internodes, the genes were assumed to add the following values to an initial value of three internodes: Gene **A**, either homozygous or heterozygous, adds 10 internodes approximately, while each of genes **B** and **C** adds 2 internodes when homozygous and 1 when heterozygous. Results were explained genically as follows:

{ Parent 1 . . **AABBCC** = $3 + 10 + 2 + 2 = 17$ internodes,
 { Parent 2 . . **aabbcc** = $3 + 0 + 0 + 0 = 3$ internodes,
 { F_1 **AaBbCc** = $3 + 10 + 1 + 1 = 15$ internodes.

or

{ Parent 1 . . **AAbbcc** = $3 + 10 + 0 + 0 = 13$ internodes,
 { Parent 2 . . **aaBBCC** = $3 + 0 + 2 + 2 = 7$ internodes,
 { F_1 **AaBbCc** = $3 + 10 + 1 + 1 = 15$ internodes.

Naturally there were many new combinations in F_2 .

NORTON (416), based on his experimental results, gives somewhat different conclusions. He postulates three following genes:

A—a: indeterminate vs. determinate growth,

L—l: tall vs. short axis,

T—t: climbing vs. non-climbing habit.

According to him, the gene **L** may be analyzed into a series of two or more genes, L_1 , L_2 etc, which have a cumulative effect. There are also various degrees of the climbing habit, but they have not been genically determined with certainty. The contorted stems of erect bush beans are probably caused by **T**. These three genes may be present in any possible combination giving rise to the various habit types of beans. Thus:

ALT . . . pole beans,

ALt . . . runner beans,

AIT . . . shoots,

Alt . . . semi-runners,

aLT } . . spreading forms with long outstretched branches,
aLt }

$\left. \begin{array}{l} \text{alt} \\ \text{alt} \end{array} \right\} \dots \text{erect, bush beans.}$

SURFACE (469) observes that among the small-eyed beans there is a complete absence of runner vines. It appears that the gene for the bush type is closely linked with the gene for the small-eyed pattern.

Resistance to Disease. According to BARRUS (523), there exists two biological forms of anthracnose (*Colletotrichum lindemuthianum*), morphologically and culturally indistinguishable. These were designated as α and β . With respect to susceptibility or resistibility to these two strains, he divided bean varieties into four groups:

- (AB) Varieties showing some resistance to both α and β strains,
- (Ab) Varieties susceptible to strain β only,
- (aB) Varieties susceptible to strain α only,
- (ab) Varieties susceptible to both strains.

BURKHOLDER (529) and McROSTIE (649, 816) made crosses between varieties whose anthracnose reactions are known. The results indicate that resistibility to either α or β strains and susceptibility to the same is caused by a single gene difference, resistibility being dominant. In crosses where either the α or β strain is concerned, a 3:1 ratio in F_2 was obtained, and where both strains were concerned, a 9:7 ratio occurred.

In the latter paper (816), McROSTIE also notes the inheritance of bean mosaic susceptibility. Crosses between Robust Pea beans highly resistant to mosaic disease, and of Flat Marrow beans, very susceptible to the same, gave F_1 plants showing a partial dominance of susceptibility over resistibility. The F_2 results indicated that complete susceptibility is produced only when two dominant genes are present in the homozygous state. Absence of both the genes gives a high degree of resistibility. Further the same author makes some observations on the inheritance of susceptibility to the dry root rot, caused by the fungus, *Fusarium martii phaseoli*. Crosses between resistant and susceptible varieties gave in F_1 susceptible plants, and in F_2 both types in a ratio that appeared to be 9:7. Most resistant F_2 plants were found to breed true to this character in F_3 .

Other Characters. As to the inheritance of several other characters studied in the bean, see TABLE XXV, in which the data obtained by several experimentors are briefly summarized. TABLE XXVI represents the results of TSCHERMAK (in 890) concerning the species-cross, *Ph. vulgaris* $\times$ *Ph. multiflorus*.

TABLE XXI.—INHERITANCE OF SEED COAT COLOR AND PATTERN IN
BEAN I. A summary of the results obtained
by TSCHERMAK (268).

Contrasted colors	F ₁	F ₂	Expected ratios
Light brown with violet navel-ring (Non plus ultra)—white (Wachsschwert)	Black mottled on light grayish yellow ground	(99) black : (33) violet : (40) brown : (39) black : (33) violet : (95) brown : (99) white	(1) Colored : white = 3 : 1 (2) Mottled : self : white = 6 : 6 : 4 (3) Black : violet : brown [a] Mottled class = 9 : 3 : 4 [b] Self class = 4 : 3 : 9
Light brown (Non plus ultra)—white (Ilsenburger)	Violet brown mottled	(5) mottled : (2) self : (5) white	6 : 6 : 4
Greenish white (Chevrier I)—light brown (Non plus ultra)	Brownish green mottled	(12) mottled : (10) self : (15) white	6 : 6 : 4
Yellow brown (Wachsdattel)—White (Mettes Schlachtsschwert)	Brownish green mottled	(29) mottled : (13) self : (13) white	9 : 3 : 4
Greenish white (Chevrier I)—violet (Schirmes Cassler)	Black mottled	(12) mottled : (9) self : (11) white	6 : 6 : 4
Yellow brown (Hundert für Eine)—White (Mettes Schlachtsschwert)	Coffee brown	(27) coffee brown : (8) yellow brown : (0) white	9 : 3 : 4
Black (Schwarze Neger)—yellow brown (Hundert für Eine)	Black mottled	(92) mottled : (75) self	1 : 1
Greenish white (Chevrier II)—violet mottled (Bunte Ilsenburger)	Brownish green to black mottled	(7) mottled : (3) self : (2) white	9 : 3 : 4
Black violet (Mont d'or black)—violet mottled (Bunte Ilsenburger)	Blackish violet mottled	(20) mottled : (6) self	3 : 1
Violet (Schirmes Cassler)—violet mottled (Bunte Ilsenburger)	Violet mottled	(24) mottled : (6) self	3 : 1
White (Weisse Ilsenburger)—greenish white (Chevrier I or II)	White	White	
Light brown (Non plus ultra)—black (Schwarze Neger)	Black	(7) black : (5) violet : (2) dark brown : (1) light brown	
Black (Schwarze Wachs)—purple mottled (Flageolet Wachs)	Black and violet mottled	(14) mottled : (6) self	3 : 1
Brown yellow (Gelbe Princess)—light brown (Non plus ultra)	Light brown	Light brown to brownish yellow	
Purple mottled (Flageolet Wachs)—purple striped (Heinrichs Riesen)	Purple mottled	(4) mottled : (2) striped	
Greenish white (Chevrier II)—yellowish brown (Hundert für Eine)	Greenish black mottled on grayish yellow ground		

Contrasted colors	F ₁	F ₂	Expected ratios
White (Weisse Wachs)—yellowish brown (Wachsdattel)	Greenish black mottled on grayish yellow ground		
White (Isenbuger) — yellowish brown (Wachsdattel)	Violet and brown mottled on yellow ground		
White (Weisse Wachs)—light brown (Non plus ultra)	Greenish black mottled on grayish yellow ground		
White (Wachs II and Weisse Isenbuger)—partially mottled (Runde violettgeäugt)	Totally mottled	(39) mottled and striped: (18) self: (27) white	9 : 3 : 4 Total pigm.: partially pigm.: white = 9 : 3 : 4 Gr. I: Gr. II: Gr. III = 2:1:1 (See the text)

TABLE XXII.—INHERITANCE OF SEED COAT COLOR AND PATTERN IN BEAN II. A summary of the results obtained by SHAW & NORTON (582).

Contrasted characters	F ₁	F ₂
<i>Pattern</i> Self-colored—self-colored	Self-colored	Self-colored
An exceptional variety 'Blue Pod Butter', was found, which when crossed with most self-colored varieties, yielded mottled progeny, none of which bred true to the mottled character.		
Mottled—mottled	Mottled	Mottled
Self-colored—mottled	Mottled	3 mottled : 1 self-colored
Mottled—white	Mottled	9 mottled : 3 self-colored : 4 white
Self-colored—white	Self-colored	3 self-colored : 1 white
" "	Mottled	9 mottled : 3 self-colored : 4 white
This exceptional variety is 'Crease black'.		
Dark colored mottled—light colored mottled	Dark colored mottled	3 dark colored mottled : 1 light colored mottled
Besides this mode of segregation, the authors observed various ratios in F ₂ , viz., 1 dark mottled : 1 light mottled ; 6 dark mottled : 3 light mottled : 3 self-colored : 4 white ; 9 light mottled : 3 self-colored : 4 white, etc.		
Self-colored—eyed	Self-colored	3 self-colored : 1 eyed
White—eyed	Self-colored	9 self-colored : 3 eyed : 4 white
<i>Yellow-black Series</i>		
Yellow—coffee brown	Coffee brown	9 coffee brown : 1 yellow
Black—yellow	Black	Black, coffee brown and yellow. (The ratio is not determined.)
Coffee brown—black	Black	3 black : 1 coffee brown or black, coffee brown, yellow and olive brown. (The ratio is not determined.)
<i>Red Series</i>		
Dark red—light red	Dark red	3 dark red : 1 light red

TABLE XXIII.—INHERITANCE OF SEED COAT COLOR AND PATTERN IN
BEAN III. A summary of the results obtained
by SIRKS (959).

Contrasted colors	F ₁	F ₂
Lemon—Wagenaar	Wagenaar	3 Wagenaar : 1 lemon
‘Wagenaar’ has a testa lemon-colored at first, but soon the color changes into grayish yellow, and a year afterwards the seeds are entirely yellowish brown.		
Wagenaar—brown	Brown	3 brown : 1 Wagenaar
Lemon—brown	Brown	3 brown : 1 lemon
” ”	”	(80) brown : (25) Wagenaar : (33) lemon [9 : 3 : 4]
Lemon—gray brown	Red brown	(46) red brown (dark and light) : (14) gray brown (dark and light) : (23) gray brown, uncolored navelring : (12) yellow brown : (5) Wagenaar : (12) lemon [27 : 9 : 12 : 9 : 3 : 4]
Brown—gray brown	Red brown	(186) red brown : (78) gray brown : (68) yellow : (13) Wagenaar
Lemon—red violet mottling on yellow	Red violet mottling on yellow brown	(106) F ₁ type : (39) yellow brown : (15) Wagenaar : (37) red violet mottling on yellow : (17) lemon : (35) yellow- white mottled with violet : (2) white with brown navelring : (18) pure white
Brown—red violet mottling on yellow	Red violet mottling on yellow brown	Several types similar to those in the above cross.
Black—red violet mottling on yellow (spontaneous cross)	Black mottling on gray	F ₁ type ; bluish mottling on gray ; dark blue violet mottling on white-yellow ; light blue violet mottling on light yellow ; gray brown mottling, here and there violet ; red mottling, here and there violet ; yellow brown mottling, here and there violet ; black ; red brown ; Wagenaar.
Brown—white	Black mottling on yellow	(97) F ₁ type : (24) red brown mottling on yellow : (10) gray brown mottling on grayish white : (17) yellow brown mottling on light yellow : (55) blue : (18) red brown : (33) gray brown : (25) yellow brown : (87) white.

TABLE XXIV.—INHERITANCE OF SEED COAT COLOR AND PATTERN IN BEAN IV. The results obtained by SAX & McPHAE (1075) and SAX (1074).

Contrasted characters	F ₁	F ₂
'Old Fashioned Yellow Eye'— 'Improved Yellow Eye'	'Piebald'	1 (O.F.Y.E.): 2 'piebald': 1 (I.Y.E.) ¹⁾
In the Old Fashioned Yellow Eye (O.F.Y.E.), the pigmented area covers about $\frac{1}{6}$ of the surface of the seed, while in Improved Yellow Eye (I.Y.E.) about $\frac{1}{4}$ of the bean is pigmented. 'Piebald' pattern (the F ₁ type) has over twice as much pigmented surface as is found in either parent.		
'Improved Yellow Eye'— white	Dark mottled	27 mottled : 9 self-colored : 12 eyed : 16 white.
In these crosses, a peculiar association of size difference of the seed with the seed coat pattern is found. All pigmented classes are significantly larger than the white F ₂ segregates. The mottled and eyed F ₂ segregates are also significantly larger than the self-colored beans. ²⁾		

- 1) SURFACE (469) from a similar cross, obtained 8 'piebald': 4 (O.F.Y.E.): 3 (I.Y.E.) in F₂. He assumed two genes, one of which is a lethal gene.
- 2) SIRKS (1305) made an analysis of the seed weight in a spontaneous hybrid, mottled purple × white, and concluded that an inhibitory gene is present in all light-seeded white, which is linked with the basic gene for pigmentation.

TABLE XXV.—INHERITANCE OF VARIOUS CHARACTERS IN BEAN.

Contrasted characters	F ₁	F ₂	Authors
<i>Flower</i>			
(See also ' <i>Seed Coat Color and Pattern</i> '))			
Carmine red—light rose	Carmine red	3 carmine red : 1 (rose, light rose, wax-like rose)	} SHAW (313)
Carmine red—rose	Carmine red	3 carmine red : 1 rose light rose	
White—white	White	White	
White—white	Light rose or rose	White, light rose & rose	

Contrasted characters	F ₁	F ₂	Authors
White—light rose	Light rose or rose	3 light rose : 1 white or 3 (light rose + rose) : 1 white	
Rose—white	Rose	3 (rose+light rose) : 1 white	
Rose—light rose	Rose	3 (rose+light rose) : 1 white	
Carmine red—white	Carmine red	3 colored : 1 white	
<i>Chlorophyll</i>			
(Green — white seed- ling)	Green	3 green : 1 white	TJEBBES & KOOIMAN (661)
<i>Pod</i>			
Green — yellow (in unripe pod)	Green	3 green : 1 yellow	{ EMERSON (39) LOCK (63) TSCHERMAK (475)
Round—flat	Round	3 round : 1 flat	TSCHERMAK (475)
Constricted—non-con- stricted	Non-constricted	Non-constricted : constricted = 3: 1 or 13 : 3	TSCHERMAK (475 967)
Blunt—sharp apex	Nearly blunt	Approximately 3 blunt: 1 sharp	TSCHERMAK (475)
Broad—narrow	Nearly broad	Segregation irregu- lar	EMERSON (39)
Long—short	Nearly long	Segregation irregu- lar	TSCHERMAK (475)
Parchmented — non- parchmented	Intermediate or nearly non- parchmented	Parchmented purely recessive (1 out of 4)	{ EMERSON (39) TSCHERMAK (475) WELLENSIEK (976)
Threshable — non- threshable	Threshable	3 threshable: 1 non- threshable	TJEBBES & KOOIMAN (966)
Many—few seeds per pod	Nearly many		TSCHERMAK (475)
<i>Seed</i>			
Green—yellow cotyle- don	Yellow (apparent* on crossed seed)	3 yellow: 1 green (se- gregation appar- ent on F ₁ plants)	TSCHERMAK (662)

TSCHERMAK (268, 475, 967) also studied the inheritance of size and shape of seeds. Two or three genes appeared to be concerned in seed size (weight). Cylindrical shape seemed to be dominant or nearly so to spherical and kidney shapes and long to cylindrical. Multiple genes are supposed to be concerned in seed shape.

TABLE XXVI.—INHERITANCE IN THE SPECIES-CROSS, **Phaseolus vulgaris** (Wachsdattel) × **Ph. multiflorus** var. **coccineus**.
After TSCHERMAK (in 890).

Contrasted characters	F ₁	F ₂
Hypogeal (♀)—epigeal (♂) cotyledon ¹⁾	Nearly hypogeal	Continuous segregation (Multiple genes.)
Long, winding (♂)—short (♀) stem	Intermediate, nearly tall	Segregation into the parental and F ₁ types, and also as 'novum' some new types (dwarf & procumbent). (Multiple genes.)
Green (♂)—yellow (♀) in unripe pods	Green	3 green : 1 yellow
Long (♂)—short (♀) flowering period	Long	Irregular segregation, long period prevailing.
Blunt (♂)—sharp pod-apex	Blunt	Irregular segregation
Long (♂)—short (♀) navel	Short	No segregation ; only short-naveled individuals.
Black marbled on light rose ground (♀)—light brown with violet tinge (♂) (seed coat)	Black marbled	Complex segregation
Pale violet (♀)—yellowish red flower	Intermediate	Segregation into red, yellowish red, pale lilac, etc. (Multiple genes.)

Phleum pratense

Female Sterility. WITTE (670) reports that female sterility is a simple recessive character to the normal condition. Crosses between hermaphrodite and male flowers resulted in a monohybrid segregation, viz., 3 hermaphrodite : 1 male.

Resistance to Disease. BARKER & HAYES (1108) found that host reaction to timothy rust, *Puccinia graminis phleipratensis*, behaves as a

1) BROTHERTON (608) found that in a similar cross F₁ showed 50% decrease in length of hypocotyl, 100% increase in length of epicotyl compared with *Ph. vulgaris*, cotyledons epigeal, plant dwarf. Long hypocotyl is incompletely dominant to the short hypocotyl.

Mendelian character. Resistibility proved to be dominant to susceptibility, giving F_2 segregation of a 3 : 1 ratio.

Phlox Drummondii

Flower Color. GILBERT (395), working at several varieties of flower color, postulated the following genes: **E** = a gene for dark eye, its absence resulting in white eye; **R** = a gene for red; **B** = a gene for blue; **I** = an intensifier of **R**-effect, and **Y** = a gene for yellow which acts only in the presence of **E**. The reds and blues are cell-sap colors, and the yellow is due to the presence of yellow chromoplasts. The most epistatic color is reddish violet with dark eye (**EBRI**).

Later, KELLY (712, 921) reported the synthesis of full-colored selfs by crossing of two white strains, of white and pink, and also of lighter colored selfs and striped dusty type. He assumed three chromogenic genes, **P**, **D** and **R**, an enzym gene **E**, and its activator **A**. **AEP** is full color, **AED** dusty, with both striped and unstriped blade, and **AER** another different full color. There is also a bluing gene and one for dark eye. He also states that cream yellow is a monogenic recessive to white, contrary to the conclusion of GILBERT.

Other Flower Characters. Most varieties of *Ph. Drummondii* have single flowers, that is, only one set of petals. Whereas KELLY (1038) obtained in his culture some extra-petalled varieties (the 'semi-double' race). Crossing of the semi-double and singles yielded diverse results, sometimes singleness being completely dominant, while at other times nearly recessive.

KELLY (712, 922) also recognized the following pair of flower characters as monogenically different from one another, the first given members being dominant:

- 1) Salver-shaped—funnel-shaped corolla,
- 2) Entire—deeply incised petals (*cuspidata*),
- 3) Normal—styleless (*astylis*).

The heterozygote between entire-petalled and *cuspidata* races is the so-called *fimbriata* variety, which gives the entire, its own and the *cuspidata* types in a ratio of 1 : 2 : 1.

The styleless plants set no seed, although pollen was abundant. The relation of this variation to the large-eyed flower is peculiar. When *astylis* is crossed with colored types having small white eye, the hybrids are the large-eyed colored types, the so-called *orbicularis*, and in F_2 *astylis*, *orbicularis* and small-eyed plants are obtained in a ratio of 1 : 2 : 1.

Phyteuma

CORRENS (29). The species-cross between *Ph. Halleri* with dark violet flowers and *Ph. spicatum* having white flowers gave in F_1 two types, 5 plants being bright blue with a violet tinge, and 4 plants violet.

Pirus Malus var.

Some earlier observations on the inheritance in apples were made by HEDRICK & WELLINGTON (239), HILDEBRAND (242), AUCHTER (672) and CRANDALL (686, 687). Recently, WELLINGTON (1230) gave a full account of the results obtained, a brief summary of which is given below.

Color of Skin. The color of apples may be roughly divided into five classes: yellow, yellow with a light red blush, yellow with one-third to one-half its surface overlaid with red, nearly solid red and reddish black. Red color usually behaves as a dominant over yellow. Red blush on fruits is possibly due to one gene. Solid reds were obtained from less highly colored parents, indicating that gametes carrying the red-gene of both parents had combined. The segregations were complex, and so it is evident that a number of genes are involved in the distribution and intensity of color.

Bloom on Skin. As regards the bloom or waxy covering on the skin, its abundance behaves as a recessive to little or no bloom. The appearance of scarf-skin, although not present on either parent, and also russetting of skin in the yellow Newton $\times$ Northern Spy cross, indicate that both characters behave as recessives.

Texture of Skin. This character is evidently inherited, but several genes appear to be involved. Several gradations in thickness occurred in F_2 . Greasy or oily skin was especially observed in the Boiken variety. Oily fruits appear to behave as a recessive to either its non-appearance or appearance in unappreciable amounts.

Color of Flesh. Possibly there are at least two yellow-genes, the presence of one giving a light yellow flesh and of two a yellow flesh. Apparently there are two kinds of whites, one that is homozygous, and one that is heterozygous for yellow. In some crosses, however, the yellow color seems to behave as a dominant. It is evident that several genes are concerned in flesh color. The red coloration which is generally minute seems to be recessive.

Texture of Flesh. The texture of flesh, like that of the skin, is

evidently dependent upon a number of genes. Coarse and tough textured seedlings were obtained frequently from crosses between varieties with fine and tender flesh. Dry flesh in apples behaves as a recessive character.

Flavor of Flesh. Sweet flavor apparently behaves as a recessive character to acid flavor, with the indication that F_1 was intermediate. Generally the presence of an aroma dominates over the lack of an aroma and flat flavor.

Size and Shape of Fruit. Large size is dominant to small size. Ribbing and obliqueness, the latter appearing infrequently, behave as recessive characters.

Habit of Growth. Weak or dwarf-like trees appeared in all normal crosses, even in the F_1 generation. The dwarf character of plants seem to be recessive, but the ratio in which they appear cannot be expressed by any simple Mendelian formula.

Date of Fruit Ripening. Early varieties, when crossed *inter se*, usually produced only early ripening seedlings, while early varieties when crossed with late varieties produced no very late ripening seedlings. Late varieties, when crossed *inter se*, produced seedlings which varied in ripening from a month or two earlier than the earlier variety to sometimes three or four months later than the late variety. Lateness seems to be dominant, but apparently a number of genes are present.

Pirus serotina var.

WELLINGTON (320), working at European pears, found that the green skin is dominant to the russet.

On the other hand, KIKUTI (1177), dealing with Japanese varieties, reached the opposite conclusion, that russet was dominant to green. The author assumed two genes **R** and **M**. **R** is a gene for russet color, its absence resulting in green. The heterozygote **Rr** is much paler than the homozygote **RR**. **M** is a gene modifying the effect of **R**, its absence weakening the color intensity. Thus the scheme of genes may be represented as :

RR(M)	constant russet,
RrM(M)	modifiable russet,
Rrmm	intermediate,
rr(M)	green.

Pisum¹⁾**COLOR (ANTHOCYANIN) INHERITANCE**

Flower. Flower colors of peas are classified into:

	<i>Wings</i>	<i>Standard</i>
1) Pink	light-red	white-pink,
2) Light-purple	light-purple	white,
3) Purple	purple-red	light-red,
4) White	white	white.

Results of crossing are summarized in TABLE XXXII.

The genes concerned are (TEDIN, 1312):

A: the basic gene for color; in itself light-purple; when **A** is absent, the flower color is white.

Ar: acting together with **A**, gives pink.

B: a gene converting pink into purple, and light-purple into violet.

When a purple plant heterozygous for the three genes, **AaArarBb**, is selfed, the following trihybrid ratio is obtained (TEDIN, 746):

AaArB	purple (27),
AaArB	violet (9),
AaArb	pink (9),
Aaarb	light-purple (3),
aa(ArB)	white (16).

According to TEDIN, the hilum of the violet-flowered individuals has an abnormal structure, and these plants show also a very poor development of the seeds.

Seed Coat. From the results of crossing shown in TABLE XXVII, we can recognize the following pairs of colors or patterns often as being monogenically different from one another. In the following account, the dominant member is always given first.

1) Gray—colorless. Gray seed coats are always associated with colored flowers, and colorless seeds with white flowers. The coloration in flowers and seed coats is caused by the pleiotropic activity of the gene **A**.²⁾

1) Exhaustive reviews of literature on *Pisum* inheritance were given by WHITE (517) and recently by WELLENSIEK (1322). The present review, therefore, presents only the main features on *Pisum* inheritance in its various phases. The symbolization of genes adopted here is mainly that of WELLENSIEK.

2) The gene **A** is not only the basic gene for flower color and seed coat color, but also for seed coat spotting, seed coat marbling, indenting of seeds, leaf axil color and pod color.

2) Dark brown—gray. The gene **J** (TSCHERMAK, 268) produces—in the presence of **A**—dark chocolate brown. White-flowered varieties with a colorless testa may contain the gene **J**, and such varieties crossed with a gray-seeded plant can give a dark brown color.

3) Orange—gray. The gene **H** (TSCHERMAK, 268) weakens the effect of **A** into orange brown, and is hypostatic to **J**. According to WHITE (517), this gene is perhaps also active in white-flowered forms. The scheme of genes of TSCHERMAK may be represented as:

AJH	dark brown	} flowers colored,
AJh	dark brown	
AjH	orange	
Ajh	gray	
a(JH)	colorless	: flowers colorless.

4) Violet—colorless (???). There are very few data on this subject. Only VILMORIN (209) assumed the gene **U** which stands for self-purple. The relation between this gene and other genes is not yet known.

5) Bright brown—red	} KAJANUS (1034).
6) Bright brown—faint brown	
7) Red—pale brown	
8) Faint brown—pale brown	

Genes assumed by KAJANUS are as follows:

A (his symbol=**R**): the basic gene for color.

Z: a gene for red color; in the presence of **B** (a gene for purple flower color, designated as **G** by KAJANUS) it causes blood-red; in the absence of **B**, red-brown.

Oh (his symbol=**O**): a gene modifying the effect of **Z** into from bright-brown to gray-green, sometimes with a tinge of orange.

Then the genic scheme is as follows:

A(B)ZO$\overline{h}$	bright brown,
A(B)Zo$\overline{h}$	red,
A(B)zO$\overline{h}$	faint brown,
A(B)zo$\overline{h}$	pale brown.

Bright brown and pale brown are phenotypically indistinguishable.

9) Purple-dotted—undotted. According to TSCHERMAK's assumption, the production of purple spotting involves two genes **A** and **F**, hence it may be present in both the white-flowered and colored-flowered varieties. KAJANUS, however, mentions that the spotting-gene (his **P**) operates only in the presence of **Z** (the gene for red seed coat). Thus:

AFZ	purple spots	} flowers colored,
Af(Z)	non-purple spots	
a(FZ)	non-purple spots : flowers colorless.	

10) Marbling—non-marbling. Marbling is a character inherited independently of the characters of the seed coats, the color of the leaf axils and the flower color. But its full expression is largely dependent upon them. LOCK (55, 78), TSCHERMAK (268), KAJANUS & BERG (639) used the symbol **M** for the marbling-gene. **M** completely manifests itself only in the presence of **A**, and in the absence of **A** gives a faint expression, called by LOCK: 'ghost-marbling.' In the absence of **Z** (KAJANUS & BERG) the marbling is very faint. The scheme of the genes may be represented thus:

AMZ	marbling,
aMZ	ghost-marbling,
AMz	very faint marbling,
(A)m(Z)	non-marbling.

11) Brown—colorless hilum. The brown hilum is always associated with colored flowers and colored seed coats. Hence this character may be regarded simply as another expression of **A**.

12) Black—non-black hilum. The black eye is associated with both colored and colorless flower and seed coat races. The black gene **PI** (designated by WHITE, and synonymous with LOCK's **D** and KAJANUS'S) is epistatic to **A**. Thus we have:

API	black hilum	} flowers colored,
Apl	brown hilum	
aPI	black hilum	} flowers colorless.
apl	colorless hilum	

Leaf-axil. Concerning the axil-color (spot), the following varieties are known:

- 1) Pink associated with pink flowers,
- 2) Purple associated with purple flowers,
- 3) Colorless (greenish white or yellowish green) associated with white flowers.

A few varieties, however, are exceptional: colored-flowered forms having colorless axils are known: e.g., Svalöf *P. arvense* No. IV (TSCHERMAK, 268), *P. humile*, *P. quadratum* (SUTTON, 205).

As to the pattern of the axil-color, two types are found (KAPPERT, 1036):

- 1) A single spot: e.g., *P. vernale*, *P. thebaticum*, *P. abyssinicum*;
- 2) A double spot, one encompassing the other: e.g., 'Riesen-delikates' and 'Mammutterbse'.

The results of crossing experiments indicate that the following pairs of characters differ monogenically from one another:

- 1) Single—ringless (colorless). TSCHERMAK (268), etc.
- 2) Double—single. KAPPERT (1036), TEDIN (1311).
- 3) Double—ringless. TEDIN (1311).

TEDIN assumed $\underline{Dw}$ (KAPPERT's X), $\underline{D}$ and $\underline{d}$ which constitute a series of triple allelomorphs, $\underline{Dw}$ standing for a double ring, and $\underline{D}$ for a single ring. $\underline{Dw}$ and $\underline{D}$ are active only when $\underline{A}$ is present. Hence we get:

$\underline{DwA}$	double ring	} flowers colored,
$\underline{DA}$	single ring	
$\underline{dA}$	ringless	
$\underline{Dwa}$ }	 ringless: flowers colorless.	}
$\underline{Da}$ }		
$\underline{da}$ }		

Pod. The colors of the immature pods of peas may be divided into: normal green, yellow, red and purple (also designated as 'violet').

Crossing experiments (TABLE XXXI) show that a pair of colors: purple vs. red, and green vs. yellow, give in F_2 a monogenic segregation, while purple vs. green, and red vs. yellow, give a digenic segregation.

WELLENSIEK (1322, 1323) mentions that his F_2 results led him to assume the following three genes, viz.,

$\underline{A}$: the basic gene for color.

$\underline{Gp}$: in the absence of $\underline{P}_1$ makes the pod green; $\underline{gp}$: in the absence of $\underline{P}_1$ makes the pod yellow.

$\underline{P}_1$: produces, in co-operation with $\underline{A}$ and $\underline{Gp}$, purple; with $\underline{A}$ and without $\underline{Gp}$ it causes red, and is without $\underline{A}$ ineffective.

The genic scheme suggested is:

$\underline{AGpP}_1$. . .	purple pod	} flowers colored,
$\underline{AgpP}_1$. . .	red pod	
$\underline{aGpp}_1$. . .	green pod	} flowers colorless.
$\underline{agpp}_1$. . .	yellow pod	

SEED CHARACTERS

Cotyledon Color. The cotyledon colors of the ripe seed of peas are classified roughly into two groups, viz., 'green' and 'yellow.' Results of crossing (TABLE XXVII) indicate the following allelomorphs:

- 1) Yellow—green,
- 2) Green—yellow (Goldkönig).

According to the interpretation of WHITE (479), two genes are involved for cotyledon colors—**G**: a gene for green pigment, and **I**: an inhibitory gene which causes the green pigment to disappear on ripening of the seed. **Y** stands for yellow pigment and so far as known is present homozygously in all varieties of peas, whether green or yellow seeded. **G** is epistatic to **Y**. Thus the varieties of colors may be represented as:

YGI dominant yellow,
Ygi recessive yellow,
YGi green.

Seed Form and Cotyledon Character. Three types of the seed form of peas are dealt with, viz.,

- 1) Smooth round to roundish (usually associated with colorless flowers),
- 2) Indented (only found in colored flowered plants),
- 3) Wrinkled (associated with white flowers).

The following pairs of characters, when crossed together, prove to be in conformity with the ordinary Mendelian rules (TABLE XXVIII).

- 1) Indented (colored flower)—smooth (colored or colorless flower).
- 2) Smooth (colorless flower)—wrinkled (colorless flower).

The indenting character, after crossing, does not segregate by seed but by plant among the individuals of the F_2 generation (F_3 of cotyledons).

For interpretation, WHITE (517) assumed the following three genes:

R: a gene for smooth seed-surface,
A } : genes for indenting seed.
L }

A peculiar relation exists between the genes **A** and **R**; viz., (1) the gene **A** is epistatic to **R**, and (2) the gene **r** is epistatic to **A**.

The scheme of the genes may be represented as:

AlR	smooth (colored flowers),
aLR	smooth (colorless flowers),
ALR	indented (colored flowers),
ALr }	 wrinkled (colorless flowers).
aLr }	

Recently, KAJANUS (1034) reports that indented forms have another gene **Z** which acts also as a gene for red seed coat color. (**Z** is identical with TEDIN's **Q**).

With respect to the cotyledon character, we owe our knowledge to the ample works carried out by KAPPERT (351, 800). He obtained results which disagree with GREGORY (30) and DARBISHIRE (92)'s statements that wrinkled seeds have compound starch grains and also with the latter's conclusion that the characters of the starch grain and of the absorptive capacity are inherited independently. KAPPERT points out that wrinkled peas have no compound starch grains, but simple grains provided with splits, and states that the following four characters are determined by one gene.

- 1) Appearance of the seed, whether smooth or wrinkled.
- 2) Capacity for water absorption, whether high or low.
- 3) Form of the starch grains, whether long or round.
- 4) Nature of the starch, whether the grains are separate or clumped.

In F_1 of the cross, smooth $\times$ wrinkled, he secured results indicating that the split form ('compoundness' according to DARBISHIRE) is nearly completely dominant to the non-split form, a conclusion contrary to DARBISHIRE's one that both types of starch grains are found in about equal proportions in F_1 seeds.

Size and Weight of Seeds. Size and weight of the seed, in general, are mutually dependent upon each other. Greater size generally means increased weight.

Results of crossing are summarized in TABLE XXIX.

According to TSCHERMAK (268), there are several genes, possibly four (**Sg₁**, **Sg₂**, **Sg₃** and **Sg₄** of WELLENSIEK)¹⁾, concerned in the seed weight. The *sativum*-type contains four genes in the homozygous condition, while the other types are in the heterozygous states, or lack one or more of the genes.

'Chenille' Character. As well known, pretty nearly all varieties of peas bear pods in which the mature seeds lie free from one another.

1) **A, B, C and D** of TSCHERMAK.

In one exceptional variety known as 'Pois Chenille', however, the pods contain free immature seeds, which when mature adhere more or less closely to one another.

According to cross-experiments of VILMORIN (210) on 'Chenille', this characteristic behaves as a simple recessive, the ordinary type being dominant. The mode of inheritance, however, is not so simple, for there are some connections between the genes for type of foliage, pigment and the 'chenille' character. (See under '*Linkage Relations*').

STEM CHARACTERS

Stem Length. The height of peas is phenotypically divided into three classes:

	Height	Stem	Nodal number
1) Talls . . .	$\pm 150-300$ cm.,	robust,	{ 40-60 of short internodes, 20-47 of long "
2) Half-dwarfs	$\pm 90-150$ cm.,	robust or delicate,	{ 20-40 of short " 10-24 of long "
3) Dwarfs . . .	$\pm 25-90$ cm.,	delicate,	8-18 of short "

From the results of crossing (TABLE XXIX), there appears to exist a monogenic difference between the following pairs of characters:

- 1) Tall—dwarf,
- 2) Tall—half-dwarf,
- 3) Half-dwarf—dwarf.

WHITE (593) reports, however, that on crossing tall with dwarf a digenic segregation appeared. As to the internode character, the results indicate that:

- 1) Long internode is completely dominant to short;
- 2) Large number of internodes is imperfectly dominant to a small number.

According to WHITE, the genes concerned are as follows:

T: 20-40 internodes.

T₁: 40-60 "

T₂: 20-30 "

t: 10-20 "

Le: long internodes.

Le₁: very long internodes.

le: short internodes.

Thus the varieties may be represented as follows:

A. Tall types,

- I. With 20-40 long internodes : LeT .
- II. „ 40-60 „ „ : LeT_1 .
- III. „ 20-30 very long „ : Le_1T_2 .

B. Half-dwarf types,

- VI. With 10-20 long internodes : let .
- V. „ 20-40 short „ : leT .

C. Dwarf types,

- VI. With 10-20 short internodes : let .

Fasciated Stem. Nearly all varieties of *Pisum* have round stems. The flowers appear from a series of successive leaf-axils. A few varieties ('Pois ture', 'Pois couronné'), however, show the fasciated stem; its lower part is not discernible from the normal one, but higher up the fasciation increases gradually, so as to make the upper part broader than the normal. The flowers of fasciated plants, instead of being axillary, are bunched together at the top of the stem, so as to give an appearance of an umbel.

There exists a monogenic difference between the fasciated form and the normal one, the former being recessive. WHITE (517) introduced the symbol Fa for this gene.

LEAF CHARACTERS

Leaf Color. The leaf color of peas is either green or yellowish green. Stem color is generally associated with leaf color, and also with unripe pod color, although yellow-podded forms may also bear green leaves. Yellow-leaved forms, however, invariably show yellow pods. WHITE (517) mentions that 'Gold von Blöcksberg' and 'Goldkönig' are typical yellow varieties.

Results of crossing (TABLE XXIX) show that the difference between yellow and green is due to the presence or absence of one gene (O). Green foliage varieties have OO , while yellow varieties oo .

As to the variegation of the leaves, the inheritance of this character is usually maternal, e.g., white-green plants found in 'Haarsteegsche' reported by SPRENGER ('16, cited by WELLENSIEK, 1322), and yellow-variegated plants obtained in F_3 of a cross between two *arvense*-forms reported by KAJANUS (1034).

In contrast with the yellow-variegation described by KAJANUS which remained constant, the variegated type reported by FRUWIRTH (694) was inconstant, sometimes giving green in the progeny.

Further, FRUWIRTH states that the white-variegation often segregates monogenically as a recessive character. WELLENSIEK (1322) denotes the gene as Wb.

The leaf color is also influenced by the presence or absence of bloom. This waxy covering which most varieties of peas possess lies not only on the leaf, but extends over the stem, pod and other parts, and gives a glaucous tint. A few varieties from which the bloom is absent are known as 'emerald'.

The crossing experiments of VILMORIN (210) and especially WELLENSIEK (1322, 1323, 1324) indicate that two genes are involved in the inheritance of bloom; in the absence of either or both, the plant is emerald.

BlW Varieties with bloom,

blW Emerald (little bloom),

Blw „ (no bloom),

blw „ (no bloom; extracted from crossing).

Form of Stipules. A form of reduced stipules was found in 'Duke of Albany' by PELLEW & SVERDRUP (1065). The reduced stipule is a recessive to the normal, and the segregation is monogenic. The gene was symbolized by WELLENSIEK as St (S of PELLEW & SVERDRUP).

Other forms of the stipules have been investigated by BROTHERTON (989, 1114). The following three forms were used in the experiments.

Gradus-type : length-breadth ratio of stipules = 1.693 ± 0.0107 .

Gradus-rogue : „ „ „ „ = 2.339 ± 0.0096 .

'Mummy' : „ „ „ „ = 2.088 ± 0.0050 .

From the results of crossing, the author assumes two genes for these ratios, X and Y. The gene X is one for the mean ratio of 2.35, and its absence results in the ratio 1.70. In 'Mummy' the recessive allelogene may be represented by x'. The genes x and x' have practically the same effect, but there is a certain essential difference in the nature of these genes. The heterozygous condition Xx is very unstable and mostly mutates into the homozygous condition of X. The cross, Gradus $\times$ Gradus-rogue, therefore, results usually in the production of rogues only in F₁ and further generations. But the gene x' is far more stable, rarely, if ever, mutating to X if it is in the homozygous x'x' condition. However, in the heterozygote Xx', although

more stable than the **Xx**, nevertheless is fairly unstable, and **x'** mutates frequently to **X**.

Another gene **Y** causes an mean ratio of 2.05, and is hypostatic to **X**.

Thus the varieties used may be represented as :

Xy Gradus-rogue,
x'Y 'Mummy',
xy Gradus-type.

Generally speaking, there is dominance of the smaller forms in these varieties.

Leaf Margin. SUTTON (205, 372) reported that the dentation of the leaf-margins, occurring in the wild form of *Pisum* proves to be a dominant to the non-dentation of various cultivated varieties. TSCHERMAK (662) mentions that this difference is due to a single gene, for which WELLENSIEK (1323) introduced the symbol **Td**.

The Acacia-type. Most varieties of *Pisum* have tendrils, while the 'Acacia'-pea which shows only one exception, has no tendrils, the place of the tendrils being taken by leaflets. Tendrilled plants behave as a simple Mendelian dominant over the Acacia-type. Gene **Tl** (WHITE, 517).

FLOWER CHARACTERS

Wing Form. PELLEW & SVERDRUP (1065) described a type, the wings of which resemble the keel. The normal type is a simple dominant to the keeled form. The gene **K**.

Number of Flowers per Single Peduncle. Most varieties of peas bear 1-2 flowers or 2 flowers per peduncle. Such early forms as 'Velocity', 'First of All' and 'Black Abyssinian' are almost totally singled flowered. Some (e.g., *P. elatius*) produces 2-3 flowers or more.

VILMORIN (209) mentioned that 1-flowered and 1-2 flowered peduncles are dominant to 2-3 flowered peduncles, these two characters being determined by the presence and absence of a single gene. This gene was designated as **En** by WHITE (517).

POD CHARACTERS

Pod Form. The forms of the pod-apex of peas are either blunt (obtuse) or acute. Most varieties with strongly curved pods, such as 'Black-eyed Marrowfat', 'Scimitar', have an acute apex, while blunt pods are characteristic of 'Nott's Excesior', 'Gold von Blöcksberg', 'French Gray Sugar', 'Ringlieder', etc.

From the results of crossing (TABLE XXXI), the following allelomorphs have been recognized:

- 1) Blunt (**Bt**) and acute (**bt**),
- 2) Curved (**Ss**) and straight (**ss**)¹⁾.

The **Ssss** plants are intermediate nearer to 'straight'. There is a partial linkage between these two genes (WELLENSIEK, 1322, 1323).

Pod Texture. This is smooth vs. constricted, parchmented vs. non-parchmented, or non-edible vs. edible.

Most varieties of *Pisum* have hard inedible pods (by development of parchment-like tissue). Non-parchment, therefore, soft edible varieties are those: 'Wachs Schwert', 'French Gray Sugar', 'Petit Pois', 'Dwarf French Gray Sugar', 'Giant Sugar', etc.

The form of the parchmented pod is smooth or inflated, while the non-parchmented one, when ripening, is considerably changed and becomes constricted.

The results obtained by VILMORIN (149), NOHARA (572) and other investigators indicate that the parchmented varieties differ from those having non-parchmented pods by the presence of either one or two genes. These genes were designated by WHITE (517) as **P** and **V**. Hard forms are **PPVV**, those without parchment-like tissue are either **PPvv** or **ppVV**.

Recently, WELLENSIEK (1322, 1324, 1325), however, found that **PPvv** and **ppVV** are phenotypically distinguished. Plants of **PPvv** have a feebly developed thin membrane, not none at all. According to him, the effect of **P** and **V** is represented as follows:

P: a thin membrane; **p**: no-membrane.

V: (with **P**) a well-developed membrane; **V** itself and **v**: no membrane.

The varieties may be represented as:

PV strong membrane,

Pv thin membrane,

p(V) no membrane.

Thickness of Pod-wall. Most varieties of peas have a thin pod-wall, while the so-called 'Pois beurre' is characterized by a thick wall. Normal thin wall is a simple dominant to thick. The gene **N** (WELLENSIEK).

Pod Diameter. As to the diameter of the pods, WHITE (517) states

1) After the designation of WHITE (1323).

that several of the wild varieties have the smallest and narrowest pods (0.8–0.9 cm.), while the sugar peas have the largest and widest ones (2.0–2.6 cm.).

The experimental data indicate that there exist several genes concerned in these differences of pod diameter.

PHYSIOLOGICAL CHARACTERS

Time of Flowering. The flowering time of peas, early or late, is highly constant under similar conditions for a definite form. There exists parallelism of the number of sterile nodes below the first flower and flowering time or number of days from sowing to blooming (TEDIN, 1088; OPPENHEIM, 826).

As to the genic analysis, the following hypotheses have been postulated:

1) TSCHERMAK's hypothesis. TSCHERMAK (208) has assumed two genes (**A** and **B**). The gene **A** ('Zugfaktor') produces intermediates, while the other **B** ('Triebfaktor') originates early flowering forms, but in the absence of **A** it has no effect. Genic formulae may be given as follows:

AABB		early,
AABb		early to intermediate,
AAbb	}	 intermediate,
AaBB		
AaBb	}	 intermediate to late,
Aabb		
aaBB	}	 late.
aaBb		
aabb		

2) HOSHINO's hypothesis. HOSHINO (409) too interpretes his results as due to the presence or absence of two genes, one of which, **A**, determines the 'proper' time of flowering in the late patent, while **B** modifies the expression of **A**, toward earlier flowering. The absence of **A** causes early flowering, and is epistatic to **b** which causes the early varieties to bloom a few days later. Thus:

aabb	}	 early,
aaBB		
aaBb		
Aabb		

AAbb	}	
AABB		
AaBb		 late.
AaBB		
AABb		

3) WELLENSIEK's hypothesis. WELLENSIEK (1322, 1323) too adopts a digenic scheme, though his conception was different from those of earlier workers. The genes assumed are:

If^* : intermediate flowering; if^* : early flowering.

Lf^* : retards the flowering, caused by If^* ; in itself ineffective.

The scheme of the genes is as follows:

$\text{If}^*\text{If}^*\text{Lf}^*\text{Lf}^*$	}	
$\text{If}^*\text{If}^*\text{Lf}^*\text{if}^*$		 late,
$\text{If}^*\text{If}^*\text{if}^*\text{if}^*$	}	
$\text{If}^*\text{if}^*\text{Lf}^*\text{Lf}^*$		
$\text{If}^*\text{if}^*\text{Lf}^*\text{if}^*$		 intermediate,
$\text{If}^*\text{if}^*\text{if}^*\text{if}^*$		
$\text{if}^*\text{if}^*\text{Lf}^*\text{Lf}^*$	}	
$\text{if}^*\text{if}^*\text{Lf}^*\text{if}^*$		 early.
$\text{if}^*\text{if}^*\text{if}^*\text{if}^*$		

Further, the author found a strong correlation between flowering time and node-number. The genes for node-number are assumed as:

Sn_1 : intermediate value; sn_1 : low value.

Sn_2 : increases the value caused by Sn_1 ; in itself ineffective.

The classification of the genotypes is perfectly analogous to that of the flowering dates. The data are explained on the assumption of a 3:1 linkage between the genes If^* and Sn_1 .

Rate of Growth of the Pollen-tube. WELLENSIEK (1322) says:—"The author (WELLENSIEK) thinks it probable that there exists a gene Pt for relatively quick growth of the pollen-tube. If so, the absence of Pt denotes normal, or as the case is, slow growth."

Immunity to Disease. HAMMERLUND (1259) made certain observations on the inheritance of resistance to a mildew, *Erysiphe communis*. A cross between a susceptible plant and an immune plant gave susceptible F_1 plants, though the degree of susceptibility is considerably weaker as compared with the susceptible parent. The F_2 progeny consisted of 475 susceptible and 3 immune plants. The segregation, how-

ever, was strongly transgressive. A similar transgressive segregation was also obtained in a cross between a strongly and a weakly susceptible plant. It was assumed that the absence of four cumulative genes (M_1 , M_2 , M_3 and M_4) results in immunity.

LIST OF GENES IN *Pisum*

According to the symbolization of WELLENSIEK (1322), we have the following genes in the pea.

- A**: the basic gene for flower color, indenting of seeds, seed-coat color, seed-coat spotting, seed-coat marbling except the ghost-marbling, leaf-axil color and also for violet and red pod color.
- Ar**: acting together with **A**, gives pink flowers.
- B**: acting together with **A**, gives violet flowers; conjointly with **A** and **Ar**, gives purple.
- Bl**: a gene for bloom; **bl**: 'emerald.'
- Bt**: blunt pod apex; **bt**: acute apex.
- Dw**¹⁾: in co-operation with **A**, gives a double ring in the leaf axils.
- D**¹⁾: with **A** gives a single ring in the leaf axils; **Dw**—**D**—**d** constitute a series of triple allelomorphs (**Dw**>**D**>**d**).
- F**: conjointly with **A** and **Z**, gives violet speckling of seed-coat.
- Fa**: normal stem; **fa**: fasciated stem.
- Fl**: gray spotting on the leaves; **fl**: unspotted.
- Fn**: 1 or 1-2 flowers per peduncle; **fn**: 3 or more.
- G**: green cotyledon color.
- Gp**: green pod; **gp**: yellow pod.
- H**: acting together with **A**, gives orange seed-coat.
- I**: an inhibiting gene for green pigments in the cotyledon.
- If**²⁾: intermediate flowering; **if**²⁾: early flowering.
- J**: in presence of **A**, gives dark brown seed-coat.
- K**: normal wings; **k**: keeled wings.
- L**: acting together with **A** and **Z**, gives indented seed-surface.
- Le**: long internodes
Le₁: very long internodes } **le**: short internodes.

1) According to TEDIN (1311).

- Lf²: retards flowering time, caused by If²; in itself ineffective.
- M: acting together with Z, gives 'ghost-marbling' of seed-coat; conjointly with A and Z, brown marbling.
- M₁—M₄¹: genes for susceptibility to mildew.
- N: thin pod wall; n: thick wall.
- O: green foliage, stem and pod; o: yellowish green.
- Oh: a gene converting red into bright brown seed-coat.
- P: thin-parchmented membrane in the pod; p: no such membrane.
- P₁: conjointly with A, gives red pod color; and with A and Gp, violet.
- Pl: gives black hilum-color; epistatic to A: brown hilum-color.
- Pt: hypothetic gene for relatively quick growth of the pollen-tube.
- R: gives smooth seed-surface; r: wrinkled surface; r is epistatic to A (indented surface), and R is hypostatic to A.
- S: seeds free in the ripe pod; s: 'chenille'.
- Sg₁—Sg₄: genes for seed-weight.
- Sn₁: intermediate value for node-number; sn₁: low value.
- Sn₂: increases the value for node-number caused by Sn₁; in itself ineffective.
- Ss²: straight pod; ss: curved pod.
- St: normal stipules; st: reduced stipules.
- T, T₁, T₂: genes for internode number.
- Td: leaves dentate.
- Tl: normal type; tl: 'acacia'.
- U: violet seed-coat.
- V: intensifying gene for P.
- W: intensifying gene for Bl.
- Wb: green foliage; wb: white-variegated.
- X: a gene for stipule size.
- Y: yellow cotyledon.
- Yr: a gene for stipule size.
- Z: acting together with A, gives red seed-coat.

LINKAGE RELATIONS³)

Several genes have been found to be linked with each other in

1) According to HAMMERLUND (1259).

2) According to WHITE (1328).

3) The haploid chromosome number in *Pisum sativum* and *P. arvense* is 7. (Vide TISCHLER, loc. cit.)

TABLE XXVII.—A SUMMARY OF THE INHERITANCE IN **Pisum** :
I. SEED COAT AND COTYLEDON COLORS.

Contrasted characters	F ₁	F ₂	Authors
<i>Seed Coat Color & Pattern</i>			
Colorless—colorless	Colorless	Colorless	BATESON <i>et al</i> (47)
Colorless—opal-tinged green	Various F ₁ plants, but never fully opal	—	
Opal—opal	Opal	—	
Colorless—grayish brown	Grayish brown	3 grayish brown : 1 white	MENDEL CORRENS (1) BATESON (47) LOCK (78) TSCHERMAK (268)
" " "	Dark brown	9 dark brown : 3 gray : 4 colorless	TSCHERMAK (268)
Colorless—gray with purple dots	Gray with purple dots	9 dotted (gray) : 7 non-dotted (3 gray + 4 white)	
Colorless—gray without dots	Purple-dotted	9 dotted : 7 non-dotted	
Colorless—orange brown	Dark brown with purple dots	Dark brown with purplish red dots, dark brown with no dots, whitish brown (gray) with no dots, colorless.	CORRENS (1)
Colorless—orange red	From almost white? to intense orange red. More or less purple dotted	Colorless, F ₁ types, orange red.	TSCHERMAK (268)
Colorless—dark brown	Dark brown	—	LOCK (78)
Colorless—gray with maple pattern	Maple pattern with or without purple dots	9 maple : 3 gray : 4 colorless	TSCHERMAK (268)
The presence or absence of the purple dots in F ₁ is dependent on the kind of colorless seed coat variety used. BATESON (47) found 'British Queen' to be a colorless seed coat variety giving F ₁ plants with purple dots, and 'Victoria' giving no dots.			
Colorless—purple	Purple	3 purple : 1 non-purple	VILMORIN (209) TSCHERMAK (268)
Gray—gray	Gray	Gray	LOCK (78)
Gray—gray with purple dots	Gray with purple dots	3 gray purple-dotted : 1 gray with no dots	LOCK (78)
Colorless—gray with maple & spots (g. m. s.)	Gray with maple & dots	(11) g.m.s. : (2) g.m. : (6) g.s. : (2) g. : (4) white (one of which was ghost-mapled). [Exp. 27:9:9:3:16]	
Gray—gray with maple	Gray with maple	3 maple : 1 non-maple	

Contrasted characters	F ₁	F ₂	Authors
Gray with purple dots — gray with maple	Gray with both mapling & spotting	(13) g.m.s. : (13) g.s. : (12) g.m. : (2) g.	TSCHERMAK (268)
Gray with purple dots — self purple	Self purple	(35) self purple : (11) gray green with violet dots : (3) gray green	FRUWIRTH (394)
Colorless—bright brown	Bright brown	3 bright brown : 1 colorless	KAJANUS (1034, 1162)
Colorless—red	Bright brown	9 bright brown : 3 red : 4 white	
Colorless — bright brown with violet dots & with brown maple (s.m.)	Bright brown, s.m.	9 s.m. : 3 m. : 3 s. : 1 white	
Bright brown—red	Bright brown	3 bright brown : 1 red	
Pale brown—red	Red	3 red : 1 pale brown	
Pale brown—bright brown	Bright brown	9 bright brown : 3 red : 3 faint brown : 1 pale brown	KAJANUS (1034, 1162)
Pale brown—colorless	Bright brown	27 bright brown : 9 red : 9 faint brown : 3 pale brown : 16 white	
<i>Hilum Color</i>			
Colorless—black (both white-flowered)	Black	3 black : 1 colorless	LOCK (78) VILMORIN (209) MEUNISSIER (723)
Colorless (white-flowered)—black (colored-flowered)	Black	3 black : 1 brown (red) or white	KAJANUS (1034, 1162) WELLENSTIEK (1322, 1324)
Brown—black (both colored flowered)	Black	3 black : 1 brown	KAJANUS (1034)
Brown—colorless	Brown	3 brown : 1 colorless	
Violet—non-violet	Violet	3 violet : 1 non-violet	TSCHERMAK (268)
KAJANUS (1034) states that TSCHERMAK's 'violet' is identical with the 'black' of other authors.			
White—white <i>Cotyledon Color</i>	Black	—	MEUNISSIER (723)
Orange yellow—light yellow	Orange yellow	—	VILMORIN (209)
Variegated—yellow	Yellow	Yellow & green	BATESON (106) MENDEL, CORRENS (1) TSCHERMAK (5) HURST (40, 41) BATESON (47) LOCK (78) etc.
Green—variegated	Green	Variegated & green	
Yellow—yellow	Yellow	Yellow	
Yellow—green	Yellow	3 yellow : 1 green	
Yellow (Goldkönig)—yellow (various forms)	Yellow	13 yellow : 3 green	
Yellow (Goldkönig)—green	Green	3 green : 1 yellow	WHITE (479, 518) WHITE (479, 518) PELLEW & SVERDRUP (1065)

TABLE XXVIII.—A SUMMARY OF THE INHERITANCE IN **Pisum** :

II. SEED FORMS.

Contrasted characters	Cotyledons			Authors
	F ₁	F ₂	F ₃	
Smooth—smooth (both white-flowered)	Smooth	Smooth	Smooth	
Smooth (white-fl.) ♀ — smooth (colored-fl.) ♂	Smooth	} Indented	9 indented (colored-fl.) : 7 smooth (white & colored-fl.)	{ TSCHERMAK (12, 22, 268) LOCK (55) BATESON (106) KAJANUS (1034)
Smooth (colored-fl.) ♀ — smooth (white-fl.) ♂	Indented			
Smooth (white-fl.) ♀ — indented (colored-fl.) ♂	Smooth	} Indented	3 indented (colored-fl.) : 1 smooth (white-fl.)	{ TSCHERMAK (12, 21) BATESON (106)
Indented (colored-fl.) ♀ — —smooth (white-fl.) ♂	Indented			
An exceptional case was reported by BATESON (106), where indented ♀ × smooth, white-flowered Nain de Bretagne ♂ gave in F₁ indented as usual, but in F₂ 3 indented: 1 smooth, instead of giving all indented seeds.				
Smooth—wrinkled (both white-fl.)	Smooth	3 smooth : 1 wrinkled (both white & colored-fl.)		{ MENDEL TSCHERMAK (5) HURST (41) BATESON (47) LOCK (55), etc.
Smooth — smooth (both colored-fl.)	Smooth	Smooth	Smooth	
Smooth (colored-fl.) — wrinkled (white-fl.)	Indented	3 indented : 1 wrinkled		LOCK (55)
Indented — indented (both colored-fl.)	Indented	Indented	Indented	
Indented (colored-fl.) ♀ — wrinkled (white-fl.) ♂	Indented	} 3 indented : 1 wrinkled (both colored-fl.)		{ TSCHERMAK (268) BATESON (47)
Wrinkled (white-fl.) ♀ — indented (colored-fl.) ♂	Smooth			
Wrinkled — wrinkled (both white-fl.)	Wrinkled	Wrinkled	Wrinkled	

TABLE XXIX.—A SUMMARY OF THE INHERITANCE IN **Pisum** :
III. SEED-, STEM- AND LEAF-CHARACTERS.

Contrasted characters	F ₁	F ₂	Authors
<i>Seed Size & Weight</i>			
Large—small	Intermediate	Intermediate (one case suggesting segregation)	BATESON (47)
Parents of about equal size (Black-eyed Marrowfat × white-flowered Mummy)	Intermediate	Segregation (the parental types, intermediates, and very much smaller seeds)	MACOUN (19)
Large—small	Large		VILMORIN (209)
Relatively big — relatively small	Intermediate	Segregation (the bigger parental type did not occur)	TSCHERMAK (967)
Small (<i>P. arvense</i>) — large (<i>P. sativum</i>)	Intermediate	Continuous segregation (<i>arvense</i> -type, intermediate types, <i>sativum</i> -type)	TSCHERMAK (12, 268)
<i>Location of the Seeds in the Pods</i>			
Free — adherent ('Pois Chenille')	Free	3 free : 1 adherent	{ VILMORIN (210) MEUNISSIER (723) WELLENSIEK (1322, 1324)
<i>Stem</i>			
Fasciated, umbellata—normal, axillary inflorescence	Normal	3 normal : 1 fasciated	{ MENDEL LOCK (55) WHITE (518) KAPPERT (1167) WELLENSIEK (1322, 1323)
Short—long internodes	Long	3 long : 1 short	{ KEEBLE & PELLEW (137) WELLENSIEK (1322, 1323)
<i>Leaf</i>			
Yellow—green	Green	3 green : 1 yellow	WHITE (518)
Green ♀—yellow-variegated ♂	Green	Green	KAJANUS (1162)
Gray-spotted—unspotted	Gray-spotted	3 spotted : 1 unspotted	TEDIN (1311)
Glaucous—glaucous	Glaucous	Glaucous	{ VILMORIN (149, 210) TSCHERMAK (268) WELLENSIEK (1322, 1323, 1324)
Glaucous—emerald	Glaucous	3 glaucous : 1 emerald	
Emerald (little bloom) — emerald (no bloom) ¹⁾	Glaucous	9 glaucous : 7 emerald (3 little bloom + 4 no bloom)	{ VILMORIN (149, 210) WELLENSIEK (1322, 1323, 1324)

Contrasted characters	F ₁	F ₂	Authors
Dentate—non-dentate margin	Dentate	3 dentate : 1 non-dentate	SUTTON (205)
'Telephone'—'Native Pea No. 1' type	'Telephone'-type	'Telephone'-type & 'Native'-type, appearing sometimes in 3:1	LOCK (55)
<i>Stipule</i>			
Reduced—normal	Normal	3 normal : 1 reduced	PELLEW & SVERDRUP (1065)
'Gradus'-type—'Mummy'	Intermediate	3 ('Mummy' + intermediates) : 1 'Gradus'	BROTHERTON (989)
'Gradus'-type—'Gradus'-rogue	'Gradus'-rogue	'Gradus'-rogue only	
'Gradus'-rogue—'Mummy'	Rogue	3 rogue : 1 non-rogue (=12 rogue : 3 intermediate : 1 broad)	
<i>Leaf Axil</i>			
Colored (single spotted) — colored	Colored	Colored	TSCHERMAK (268) MENDEL & LOCK (95)
Colored—colorless (colored-fl.)	Colored	3 colored : 1 colorless	
Colored (colored-fl.)—colorless (white-fl.)	Colored	3 colored : 1 colorless	
Colorless — colorless (both similar types)	Colorless	Colorless	TSCHERMAK (268)
Colorless (colored - fl.) — colorless (white-fl.)	Colored	9 colored : 7 colorless (3 colored-fl. + 4 white-fl.)	
Single—double ring	Double	3 double : 1 single	KAPPERT (1036) TEDIN (1312)
Double—no ring (colorless)	Double	3 double : 1 no ring	
'Acacia'			VILMORIN (149, 210)
Tendrilled—non-tendrilled ('Acacia')	Tendrilled	3 tendrilled : 1 'Acacia'	VILMORIN & BATESON (211) PELLEW (308) WHITE (518) MEUNISSIER (938)

1) Johnson's British Empire × Pois à brochettes, Johnson's British Empire × Châtenay by WELLENSIEK; Emerva × Johnson's British Empire, Emerva × Pois à brochettes by VILMORIN.

TABLE XXX.—A SUMMARY OF THE INHERITANCE IN **Pisum** :
IV. GROWTH HABIT.

Contrasted characters	F ₁	F ₂	Authors
Tall—tall	Tall	Tall	WHITE (593)
Tall—half-dwarf	Tall	3 tall : 1 half-dwarf	{ TSCHERMAK (12) LOCK (55)
BATESON (47, 106), however, reports that similar crosses gave intermediate in F ₁ and doubtful segregation in F ₂ , giving in some cases three classes, i.e., tall, dwarf and half-dwarf.			
Tall—dwarf	Tall, often considerably taller than the tall parent	3 tall : 1 dwarf	{ MENDEL HURST (41) BATESON (47) LOCK (55) KAPPERT (1167)
Tall—dwarf	Tall with long internodes	9 tall, long nodes: 3 half-dwarf, long nodes: 3 half-dwarf, short nodes: 1 dwarf, short nodes	WHITE (593)
Half-dwarf with few long nodes — half-dwarf with many short nodes	Tall with long internodes	9 tall, long nodes: 3 half-dwarf, long nodes: 3 half-dwarf, short nodes: 1 dwarf, short nodes	{ KEEBLE & PELLEW (137) TEDIN (1088)
Half-dwarf—half-dwarf (both similar types)	Half-dwarf	Half-dwarf	WHITE (593)
Half-dwarf—dwarf	Half-dwarf	3 half-dwarf : 1 dwarf	{ TSCHERMAK (12) BATESON (47, 106) KAPPERT (711)
Dwarf—dwarf	Dwarf	Dwarf	WHITE (593)

TABLE XXXI.—A SUMMARY OF THE INHERITANCE IN **Pisum** :
V. POD CHARACTERS.

Contrasted characters	F ₁	F ₂	Authors
<i>Pod Color</i>			
Green—green	Green	Green	{ MENDEL TSCHERMAK (268) PH. DE VILMORIN (209)
Green—yellow	Green	3 green : 1 yellow	{ HAMMERLUND (1015) WELLENSIEK (1322, 1323)
Green—purple	Purple	Purple, green, green-edged purple, purple-edged green, green & purple 'ghostly' colored. (No actual numbers were mentioned.)	LOCK (95)

Contrasted characters	F ₁	F ₂	Authors
Green—purple	Purple	(10) purple in different degrees : (5) green	TSCHERMAK (268)
Green—purple	Green	(39) green : (10) purple or purple-splashed	FRUWIRTH (394)
Green—purple	Purple	3 purple : 1 green (actual numbers were not mentioned.)	PH. DE VILMORIN (209)
Green—purple	Purple	9 purple : 7 green	WELLENSIEK (1322, 1323)
Violet - or pink - tinged in unripe pods (white-fl. — green (pink-fl.))	Violet	Violet, green, violet-tinged, yellow and red. (No ratios were mentioned)	JACQUES DE VILMORIN (853)
Yellow—purple	Purple	9 purple or purple-dotted : 7 yellow	TSCHERMAK (268)
Yellow—purple	Purple	27 purple : 9 red : 21 green : 7 yellow	WELLENSIEK (1322, 1323)
Green—red	Purple	27 purple : 9 red : 21 green : 7 yellow	
Purple—red	Purple	3 purple : 1 red	
Red—yellow	Red	9 red : 7 yellow	
<i>Pod Form</i>			TSCHERMAK (12)
Blunt—acute (apex)	Blunt	3 blunt : 1 acute	BATESON <i>et al</i> (47)
			LOCK (42, 95)
			KAPPELT (1167)
			WELLENSIEK (1322, 1323), etc.
Straight—curved	Straight (imperfect dominant)	3 (straight + intermediate) : 1 curved	WELLENSIEK (1322, 1323)
<i>Pod Texture</i>			WHITE (1328)
Parchmented—parchmented	Parchmented	Parchmented	MENDEL
Parchmented—non-parchmented	Parchmented	3 parchmented : 1 non-parchmented	TSCHERMAK (12)
			BATESON <i>et al</i> (47)
			LOCK (95)
			PH. DE VILMORIN (149)
Non-parchmented — non-parchmented	Parchmented	9 parchmented : 7 non-parchmented	PH. DE VILMORIN (149)
			NOHARA (572)
Strong membrane—strong-membrane	Strong	Strong	
Strong membrane — thin membrane	Strong	3 strong : 1 thin	
Strong membrane — no membrane ¹⁾	Strong	3 strong : 1 no membrane	WELLENSIEK (1322, 1324, 1325)
Strong membrane — no membrane ²⁾	Strong	9 strong : 3 thin : 4 no membrane	
No membrane—thin membrane	Strong	9 strong : 3 thin : 4 no membrane	
<i>Pod Wall</i>			
Thin—thick	Thin	3 thin : 1 thick	WELLENSIEK (1322, 1324, 1325)
<i>Inside of Pod</i>			
Wooly—non-wooly	Wooly	—	SUTTON (205, 372)
<i>Pod Size</i>			
Broad—narrow	Intermediate, nearer to the broad parent	Continuous segregation	TSCHERMAK (12)
			LOCK (55, 95)

1) Pois à cosse jaune × Pois à cosse violette ; Pois à cosse jaune × Pois à cosse rouge. 2) Pois turc × Slierpeul.

TABLE XXXII.—A SUMMARY OF THE INHERITANCE IN **Pisum** :

VI. FLOWER CHARACTERS.

Contrasted characters	F ₁	F ₂	Authors
<i>Flower Color</i>			
Purple—purple	Purple	Purple	{ LOCK (95) KAJANUS & BERG (639)
Purple—pink	Purple	3 purple : 1 pink	{ KAJANUS (1034) KAPPERT (1167) WELLENSIEK (1322, 1323)
Purple—white	Purple	3 purple : 1 white	{ MENDEL TSCHERMAK (207, 268) KAJANUS & BERG (639)
" "	Purple	9 purple : 3 pink : 4 white	{ KAJANUS (1034) KAPPERT (1167) WELLENSIEK (1322, 1323)
Pink—pink	Pink	Pink	{ TEGIN (746)
Pink—white	Purple	9 purple : 3 pink : 4 white	{ LOCK (95) TSCHERMAK (207, 268) KAJANUS & BERG (639)
Light purple—white	Pink	9 pink : 3 light purple : 4 white	{ TEGIN (746) KAJANUS (1034) KAPPERT (1167) WELLENSIEK (1322, 1323)
" " "	Light purple	3 light purple : 1 white	{ TEGIN (746)
" " "	Purple	27 purple : 9 violet : 9 pink : 3 light purple : 16 white	
White—white	White	White	
<i>Flowering Time</i>			
Early—late	Intermediate or near the late parent	3 early : 9 intermediate : 4 late	TSCHERMAK (208)
" "	Intermediate	(63) early : (128) interm. : (1) late	KEEBLE & PELLEW (137)
" "	"	(63) early : (186) interm. : (279) late	LOCK (55)
" "	Nearly late	(258) early : (557) late = 6 : 10	HOSHINO (409)
Low—high node-number	High	3 high : 1 low	{ OPPENHEIM (826) TEGIN (1088)
Early (low number)—late (high)	Intermediate (high)	4 early : 9 interm. : 3 late (4 low : 9 interm. : 3 high)	{ WELLENSIEK (1322, 1323)
<i>Number of Flowers per Single Peduncle</i>			
1 or 1-2 flowered — 2-3 or more flowered	1 or 1-2 flowered	3 (1 or 1-2 fl.) : 1 (2-3 or more fl.)	{ VILMORIN (209) TSCHERMAK (662)
<i>Wing</i>			
Normal—keeled	Normal	3 normal : 1 keeled	PELLEW & SVERDRUP (1065)

Pisum. A summary of results obtained by several investigators is given here.

<i>Linked genes</i>	<i>Crossing over %</i>	<i>Authors</i>
1) $\left\{ \begin{array}{l} \text{If}^{1)} - \text{A} \\ \text{Lf}^{2)} - \text{A} \end{array} \right.$	25.0	TSCHERMAK (208).
$\text{A} - \text{Gp}^{3)}$	12.5	HOSHINO (409).
$\text{A} - \text{Yr}$	1.5	HAMMERLUND (1015).
2) $\text{Ti} - \text{R}$	25.0	BROTHERTON (989).
$\text{R} - \text{Bt}$	1.5	VILMORIN & BATESON (211), PEL- LEW (308), WHITE (517, 518).
3) $\text{S} - \text{W}$	11.0	KAPPERT (1167).
$\text{W} - \text{Le}$	not quite sure	VILMORIN (210), WHITE (517, 518), WELLENSIEK (1322, 1324).
4) $\text{K} - \text{W or Bl}$	WELLENSIEK (1322, 1324).	
5) $\text{G} - \text{O}$	20.0	PELLEW & SVERDRUP (1065).
6) $\text{St} - \text{B}$	11.0	WHITE (517, 518).
$\text{B} - \text{V}$	28.6	PELLEW & SVERDRUP (1065).
7) $\text{If}^* - \text{Sn}_1$	43.5	} WELLENSIEK (1322, 1323).
8) $\text{Gp} - \text{Cp}$	25.0	
$\text{N} - \text{Cp}$	33.0	
$\text{Gp} - \text{N}$	33.0	
9) $\text{Pl} - \text{Fl}$	50.0	TEDIN (1311).
	5.0	

Plantago major

Abnormal Spikes. The normal form of plantain has long simple spikes and small bracts. HAMMERLUND (790) observed the following three abnormal forms: (1) a form with branched spikes, (2) a form with bracts replaced by leaves, the spike being thus pyramidal, and (3) a form with bracts replaced by leaves and spike shortened to rosette. All these forms were found to be self-fertile. Cross-experiments showed that the branched form differs from the normal in a single gene, the latter being dominant. Pyramidal and normal gave in F_2 a dihybrid ratio of 12 normal : 3 rosetted : 1 pyramidal. For inter-

1) TSCHERMAK's A.

2) HOSHINO's A.

3) A and Gp are occasionally inherited independently.

pretation of these results three genes were assumed: **N** inhibits the branching of the spike, **B** inhibits the bracts from developing into leaves, and **C** shortens the spindle of the spike, and produces a rosetted spike. **B** is epistatic to **C**. Thus the scheme of genes suggested is:

NBC	}		normal,
Nbc	f		
nBC			branched,
Nbc			pyramidal,
NbC			rosetted.

Abnormal Leaves. 1) *Incisa* type. IKENO (1338). In the normal plantain, the leaves are broad, egg-shaped, and about $\frac{2}{3}$ longer than the breadth. In the *incisa* type, however the leaves are irregularly and more or less deeply incised and slightly broader than long. Crosses between these types gave an intermediate form in F_1 , and in F_2 a monohybrid segregation into *typica*, intermediate and *incisa* forms in a 1 : 2 : 1 ratio.

2) *Contorta* type. IKENO (1028). The *contorta* form is characterized by leaves which wind in an abnormal way either to the right or to the left. The direction of the winding proved non-heritable. *Contorta* was found to differ from *typica* in a single recessive gene. Another peculiar feature of this type is that *contorta* often produces some *typica* plants in the self-fertilized offspring. *Typica* plants produced in such a way (i.e. reversion) were found to be always heterozygotes (**Tt**). In two cases, however no homozygotic individuals were obtained in their offspring. The original two plants, genotypically *typica*, possessed vegetatively a *contorta*-rosette, and were characterized by the following genetical features (also IKENO, 1157).

(a) The offspring of these plants always consisted of two types, one *typica*, the other *contorta*, in which the number of *contorta* was usually much greater than those of *typica*, the average ratio being equal to 70 : 30%.

(b) These strains, whether they may be phenotypically either *typica* or *contorta*, when crossed with the normal *typica* usually gave *typica* only, with some exceptional cases in which a few *contorta*-plants were included.

(c) When crossed with the normal *contorta*, they gave both *typica*- and *contorta*-types.

These peculiar results were explained on the assumption of two genes, **L** and **I**, which were supposed (1) to have simultaneously occurred in the original two plants through mutation, (2) to be closely linked

with **T** and **t**, respectively, (3) to act together as balanced lethals, and further (4) to partially inhibit the effect of **T** (the intensity of their inhibiting action being variable according to the environmental conditions). On this hypothesis, the original plants are assumed to have the constitution **TL.tl**. Accordingly the results from self-pollination and crossing, mentioned above, may be explained thus:

(a) **TL.tl**, selfed = **TL.TL** + **tl.tl** + 2 **TL.tl**, in which the first two zygotes are not viable, and consequently the offspring consists only of **TL.tl**. They are phenotypically either typica or contorta, owing to the partial inhibiting action (which is subject to fluctuation according to the environment) of **L** and **l** on the effect of **T**.

(b) **TL.tl** × **TT** (eutypica) = **TL.T** + **tl.T**, in which the first zygote is non-viable owing to the lethal action of **L** (**L** and **l** act as lethals, though present in simplex dose when **T** or **t** is in homozygous condition). The offspring (**tl.T**), therefore, is typica, for the influence of **l** is much more reduced than of **L**. The exceptional cases in which a few contorta appeared, may be ascribed to the gametes of **Tl** and **tL** which are produced by the crossing over between these genes. These gametes, when combined with **T**-gametes of the normal typica, would give the zygotes **Tl.T** (non-viable) and **tL.T** (viable), thus resulting in contorta and typica.

(c) **TL.tl** × **tt** (eucontorta) = **TL.t** (viable) + **tl.t** (non-viable). Consequently the offspring consists of contorta and typica.

Dwarfishness. IKENO (707, 1028) observed a dwarf form, in which the leaves are rounder, thicker and very green, and the spikes much shorter than in typica. This form was called contracta. The cross of contracta with typica followed the monogenic scheme, typica being dominant. Here also reversion to typica (**a** → **A**) was observed.

Chlorophyll Deficiencies. IKENO (496, 1028) showed that the normal green condition is completely dominant to the variegation. The F_2 results suggested the existence of two duplicate genes, **G** and **H**, for development of chlorophyll. Thus:

GH	} green (phenotypically indistinguishable),
Gh	
gH	
gh	
	 variegated.

Variegata often produced green plants through reversion. In some cases the transformation of these two genes was found to occur simultaneously (**gghh** → **GgHh**).

Polemonium coeruleum

The following pairs of characters were found to differ monogenically from one another, the first given members being dominant:

1) Color of corolla (and style): blue—white. DE VRIES (8, 56), DAHLGREN (536, 1124), OSTENFELD (1062).

2) Shape of leaf: pinnate (or more correctly pinnatifid)—bipinnate. OSTENFELD (1062), DAHLGREN (1124).

3) Form of petal: normal—small, narrow and pointed. DAHLGREN (1124).

4) Color of leaf: green—lethal pale green (chlorina). DAHLGREN (1124).

CORRENS (29) made crosses between *P. coeruleum* and *P. flavum*. Both blue and white corolla colors of *P. coeruleum* proved to be dominant to the yellow color of *P. flavum*, which is due to a chromoplast color. These hybrids were sterile.

Portulaca grandiflora

Flower Color. YASUI (748) made crosses, pale yellow $\times$ white, and obtained magenta in F_1 . In F_2 magenta showed segregation into three colors, magenta, yellow and white in a dihybrid 9 : 3 : 4 ratio.

Later, IKENO (796, 915, 1155) worked with several color varieties: orange, yellow, red, magenta, flesh-colored and white. A number of crosses were made between these varieties. The main results in F_1 and F_2 were as follows:

Crosses	F_1	F_2
Orange $\times$ white	$\rightarrow$ orange	$\rightarrow$ 3 orange : 1 white.
Yellow $\times$ white	$\rightarrow$ yellow	$\rightarrow$ 9 yellow : 3 orange : 4 white.
Red $\times$ orange	$\rightarrow$ red	$\rightarrow$ 3 red : 1 orange.
Magenta $\times$ white	$\rightarrow$ magenta	$\rightarrow$ 9 magenta : 3 orange : 4 white.
Magenta $\times$ orange	$\rightarrow$ magenta	$\rightarrow$ 3 magenta : 1 orange.
Flesh $\times$ orange	$\rightarrow$ flesh	$\rightarrow$ 3 flesh : 1 orange.
Flesh $\times$ white	$\rightarrow$ flesh	$\rightarrow$ 9 flesh : 3 orange : 4 white.

It was found that the color of floral parts and vegetative organs are correlated to each other. For interpretation of these results, IKENO assumed five genes, **C**, **G**, **R**, **B** and **F**. **C** is the basic gene for color, and by itself produces orange. **G** lightens **C**, and produces yellow. **F** gives flesh-color with **C**. **R** produces red with **C**, and **B** converts red

into purple. **R** and **B** are generally in complete linkage, as shown in the F_2 results from magenta (**CRB**) $\times$ orange (**Cr**b****). White lacks **C** but may carry the other genes. Among white-flowered plants, IKENO recognized four distinct groups. 'White-I' is pure white, free from pigment in petals, filaments and styles, likewise in vegetative parts, such as leaves and stem, and the cross with orange gives orange which shows normal segregation. 'White-II' often shows a few magenta-colored stripes or spots on the white petals, or has magenta-colored filaments. The cross, 'white-II' $\times$ orange, gives purple which shows segregation into 9 magenta : 3 orange : 4 white. 'White-III' is phenotypically indistinguishable from 'white-I', but the cross with orange gives orange in F_1 and a ratio of 9 orange : 3 'pseudo-white' : 4 white in F_2 . 'Pseudo-white' has reddish pigment in leaves and stem, and its petals are white except for the purple spots in the base, and the filaments and styles are also purple. 'Pseudo-white' $\times$ 'white-I' gives orange and in F_2 orange, 'pseudo-white' and white in a 9 : 3 : 4 ratio. The gene **Ps** was assumed for 'pseudo-white'. The plants containing the gene **C** and **Ps** in homozygous condition—**C(C)PsPs**—are 'pseudo-white', while the heterozygous **Ps** has no effect.

The 'special white' race reported by ENOMOTO (1004) is quite similar in appearance to IKENO's 'pseudo-white.' But its mode of inheritance is very peculiar. 'Special whites' always proved to be heterozygous, and when selfed gave about 2 'special whites' to 1 normal white. It is supposed that the homozygous condition is not viable.

Doubleness of Flowers. According to the observations of YASUI (748), there are two types of doubleness, one with a small number of extra petals and with normal functional male and female organs, and the other with a luxuriant mass of petals, apparently formed at the expense of the stamens, an abortive pistil and a few anthers containing good pollen. These two types of double flowers usually occur in the different individuals, but sometimes on the same plant, and perhaps undergo a change with the age or vigor of the plant. Crosses between these doubles and the normal singles with five petals showed that the character doubleness differs from the character singleness in a single gene, the former being dominant.

Dwarfishness. BLAKESLEE (676) found that the normal growth habit is caused by a single dominant gene which is absent from the dwarf plants. The dwarfs showed no red in the stem (except in the seedling stage), while the corresponding normals did.

The same author, together with AVERY (527), also reports that some of the dwarf offspring bear reverting branches; selfed seeds from the reverting branches produce both dwarfs (with short internodes) and normal plants (with long internodes), as well as occasional dwarfs that show reverting branches.

*Linkage Relations.*¹⁾ As already briefly stated, the genes for flower color, **R** and **B** were found to be in linkage. This is the only case of linkage found in *P. grandiflora*. IKENO showed that in F_2 of the cross, magenta $\times$ orange, and the back-cross of F_1 to a double recessive white, the linkage between them appeared to be complete, while when F_2 magenta heterozygotes were used in back-crosses different results were obtained, causing the production of a certain number of unexpected red plants. Thus the back-cross, F_2 purple heterozygote $\text{♀} \times$ the double recessive white ♂ , gave 16% of crossing over, while in its reciprocal crosses 9% of crossing over was obtained. The cause of these peculiar results has not been explained.

Primula sinensis

Flower Color. The bulk of our knowledge as regards the inheritance of color in this genus is due to the work of GREGORY. The following table (TABLE XXXIII) presents a summary of the results which were published in 1911 by the same investigator (171).

The color varieties used by the author were as follows:

Pale colors: Various shades of pink, of which 'Reading Pink' is the deepest.

Full colors: Salmon-pink. Rosy-magenta. Deep crimson ('Crimson king'). Red ('Orange king').

Color uncertain: 'Ivy-leaf,' very pale colored flaked?

Whites: Recessive white ('Snowdrift'). Dominant white ('Double white,' 'Primrose Queen,' 'Queen Alexandra').

Patterns: 'Sirdar,' a white-edged type in which the pigment (magenta or crimson) occurs in minute dots. 'Duchess,' in which the pigment occurs as a flush around the eye of the corolla.

The results of crossing indicate the following fact:

- 1) Full colors are dominant to pale colors.
- 2) Pale pink is dominant to white.
- 3) Magenta is the most epistatic color, being dominant to rosy-magenta, crimson, salmon and red.

1) The chromosome number of this species has not yet been determined.

TABLE XXXIII.--THE INHERITANCE OF FLOWER COLOR IN **Primula**.
A summary of results obtained by GREGORY (171).

Contrasted colors	F ₁	F ₂ (observed)	F ₂ (expected)
Pale pink — white ('Snowdrift')	Pale-pink	(51) pale pink : (16) white	3 : 1
White ('Ivy-leaf') — white ('Snowdrift')	Faint-colored	(144) colored : (129) white	9 : 7
Suggestion is made that 'Ivy-leaf', instead of being white, may have the pale pink color in the flaked condition.			
Pale pink—red	1) magenta only, or 2) red only, or 3) (14) magenta : (16) red		1 : 1
Salmon - pink — white ('Snowdrift')	Magenta	(73) magenta : (22) salmon : Colored stem (19) pale pink : (10) white green stem	9 : 3 : 3 : 1
Rosy - magenta — white ('Snowdrift')	Magenta	1) (51) magenta : (32) rosy-magenta : (14) pale pink : (4) white Colored stem green stem 2) (111) magenta : (40) rosy-magenta : (40) pale pink : (6) white Colored stem green stem	In the colored stem class, magenta : rosy-magenta = 9 : 7. In the colored stem class, magenta : rosy-magenta = 3 : 1.
Deep crimson ('Crimson King') — rosy-magenta	Magenta	Various shades of magentas and reds, also 'Strawberries'.	
The 'Strawberry' is a curious parti-colored type, in which irregular masses of full color are distributed over a lighter colored ground, and occur only in a small number, probably as one in 64 of the total offspring.			
Deep crimson ('Crimson King') — red ('Orange King')	Deep crimson	(55) crimson : (14) red	3 : 1
Deep crimson ('Crimson King') — white ('Snowdrift')	Magenta	(225) magenta : (82) red : (108) pale pink + white	9 : 3 : 4
Red ('Orange King') — white ('Snowdrift')	Magenta	(111) full colored : (33) 'Sirdar' : (5) 'Orange King' : (29) pink : (52) pale pink : (12) white	The last two: the remainders = 1 : 3
White ('Giant White') — white ('Snowdrift')	White	(51) white : (13) magenta : (3) 'Sirdar': Red stem	In the red stem class, white : magenta = 3 : 1

Contrasted colors	F ₁	F ₂ (observed)	F ₂ (expected)
White ('Primrose Queen') — white ('Snowdrift')	White	(8) pale pink : (37) white Stems not fully colored (66) white : (13) magenta : Red stem (5) 'Sirdar' : (7) pale pink : (36) white Stems not fully colored	In the red stem class, white: magenta = 55: 9
Dominant white—colored, green stigma	White or tinged-white with green stigmas	(782) white and tinged-white : Green stigma (271) colored	3 : 1
Dominant white—colored, red stigma	White or tinged-white with green stigmas	(193) white and tinged-white : Green stigma (65) colored : (61) 'Duchess' and 'Buller' red stigma forms : (21) colored	9 : 3 : 3 : 1
In the 'Duchess' and 'Buller' forms, the peripheral part of the corolla is white or tinged, the central part flushed, with red stigma. The former is homozygous for the peripheral inhibiting gene, while the latter is heterozygous.			
'Duchess'—white ('Snowdrift')	White or tinged-white	(117) white and tinged- Green white : (47) colored : stigma (37) tinged-white, colored red stigma : (47) white; (14) 'Sirdar' green stigma : (18) tinged-white : (7) red stigma 'Sirdar': 24 pale pinks: 56 pure white	The observed numbers were far from those expected. In the red stem class, green stigma: red stigma was considerably > 3:1, while in the 'Sirdar' types, the ratio was slightly < 3:1. No explanation exists.
Colored, green stigma—colored, red stigma	Colored, green stigma	(315) colored, green stigma : (116) colored, red stigma	
'Ivy-leaf' — deep crimson ('Crimson King')	Magenta	(334) self-colored : (101) flaked: Red stem (79) pale pink : (34) white, light flaked pale pink : (4) white stem	Self-colored : flaked = 3 : 1

Contrasted colors	F ₁	F ₂ (observed)	F ₂ (expected)
'Ivy-leaf'—dominant white ('Primrose Queen')	White	(136) white: (30) magenta flakes: Red stem 44 white green stem	In the red stem class, white: flaked = 13 : 3
'Ivy-leaf'—recessive white ('Snowdrift')	Faint-colored	(144) colored : (129) white and flaked	9 : 7

The interrelations between self-colors, flakes and white were explained on the assumption of the following genes : $Y-Y'-y$ =a series of multiple allelomorphs ; Y , with X , giving self-colors, and Y' , with X , giving flakes ; and R =an inhibiting gene for colors. Assuming the constitution of the parents to be 'Snowdrift'= xYr , 'Primrose Queen'= XyR , 'Ivy-leaf'= XYr , then we get:—

- 1) 'Snowdrift' $\times$ 'Primrose Queen'. $F_1=XxYyRr$, giving in F_2 9 self-colored : 65 white.
- 2) 'Ivy-leaf' $\times$ 'Primrose Queen'. $F_1=XXYyRr$, giving in F_2 3 flake : 13 white.
- 3) 'Ivy-leaf' $\times$ 'Snowdrift'. $F_1=XxYYrr$, giving in F_2 9 self-colored : 7 flaked and white.

4) White may be dominant or recessive to colored.

5) 'Sirdar' and 'Duchess' types are recessive to full colors.

Dominant whites are usually characterized by the red color in the stem. According to KEEBLE & PELLEW (136), however, a green-stemmed white variety, 'Pearl', is a dominant white, and a full red-stemmed white, 'Snow King', may be recessive. Crosses between two white varieties, 'Snow King' and 'Snowdrift' gave colored (magenta) plants in F_1 .

GREGORY, DE WINTON & BATESON (1012) made some further observations on the color inheritance. They worked with two varieties of blue, one with soluble anthocyanin in the epidermis of the petals, and the other containing anthocyanin in a solid form. The latter form was now called slaty. It was found that the slaty plants, not real blue, are recessive to crimson. Genically the relations of the colors were represented thus :

BR magenta,
 bR crimson (now called 'red'),
 Br blue,
 br slaty.

The interrelations of these colors to the red of 'Orange King' have not been completely analyzed, but a form nearly resembling red exists

which is recessive to slaty. The blue and slaty have light reddish stems. In association with the dark red stem, these forms are modified and assume a peculiar appearance. The petals of such plants, both blue and slaty, apart from a uniform zone round the eye, are mottled and distinctly redder.

The same authors also described a peculiar variety, called 'Harlequin.' In this type, one, two or rarely three of the petals are fully or almost fully colored, the other petals being white or whitish. The colored petals are of the full size, whereas the pale petals are smaller in various degrees, being sometimes much reduced in size. The 'Harlequin' is a simple recessive to the normal type.

Stem Color. According to the observations of GREGORY (171), there are a number of varieties as to stem coloration: colorless (green), 'faint' colored, 'Sirdar,' full purplish-red (light and dark), blue and true red. Between these colors of the stem and those of the flower was seen a close correlation, in that fully colored flowers are only produced by plants having fully colored stems. Of these light magentas and crimsons can be borne on both light- and deep-stemmed plants, while deep flowers can only be borne on deep-stemmed plants. The stem color of 'Sirdar' is restricted to the collar and bases of the petioles, and is associated with the white-edged flower type. In the races which have blue stems, the flowers have a corresponding color, while the clean red stem is limited to the strain known as 'Orange King' which has also true red flowers.

TABLE XXXIV—INHERITANCE OF STEM COLOR IN *Primula sinensis*.
After GREGORY (171).

Contrasted colors	F ₁	F ₂	Genes involved
I. Red — green	Red	36 red : 9 faint : 19 green, or 9 red : 7 non-red	C, R and Q
II. Faint—green	Faint	3 faint : 1 green	Q
III. Red — faint	Red	3 red : 1 faint	R
IV. Red — green	Red	3 red : 1 green	R
V. Red — green (‘Snowdrift’)	Red	9 red : 3 ‘Sirdar’: 3 faint: 1 green, or 9 red : 7 light (including ‘Sirdar’)	C, F and Q
VI. Red — light (‘Ivy-leaf’)	Red	3 red : 1 light	The gene was not symbolized.
VII. Red — true red (‘Orange King’)	Red	3 red : 1 true red	”
VIII. Deep-red—light (‘Ivy-leaf’)	Light	3 light : 1 deep red	L, according to GREGORY <i>et al</i> (1912).

In a lower type of stem color, called 'faint,' the color is pronounced only in the young petioles, and the flowers have a pale color. Green-stemmed plants are usually associated with white flowers but often with pale-colored flowers.

A series of crosses between these varieties were made by the author, which gave the results summarized in the above table (TABLE XXXIV).

It is evident from Cross I that the production of stem color depends on at least two complementary genes. The basic gene **C**, in presence of **Q**, produces the faint color, and in presence of **R**, the purplish red color. The 'Sirdars', which appeared in F_2 of Cross V, were regarded as lacking the gene **F** which effects the even distribution of the color in the stems and flowers. **F** was assumed to be epistatic to **R** and ineffective in its absence. Thus the scheme of the genes may be represented as:

CRF(Q)		full red,
CRf(Q)		'Sirdar,'
Cr(F)Q		faint,
Cr(F)q	}	 green.
c(RFQ)		

Color in the Ovary, Style and Stigma. In the same paper, GREGORY reports that red color in these organs is recessive to green. This is caused by a single inhibiting gene, **G**. Later GREGORY *et al* (1912) found that there are certain connections between stigma- and petal-color. The deep spots of color external to the eye are not fully developed unless **G** is absent. Full red and dark blue flowers are only found when **G** is absent.

Heterostylism. There are two forms of flowers in *P. sinensis* which are usually referred to as long- or 'pin' styled and short- or 'thrum' styled respectively. In the long-styled form the style is long, the stigma usually standing in the mouth of the corolla tube, while the anthers are at the base of the tube. In the short-styled form, the style is very short, extending only a little way into the tube, while the anthers are situated near the mouth of the tube. There is a structural difference between the pollen grains of the two types, those of the short-styled plants having a larger diameter than those of the long-styled plants.

BATESON & GREGORY (46) and later GREGORY alone (1911) showed that the inheritance of the characters of long and short styles is of a simple Mendelian type, the short style being dominant. Thus:

Pure-short-styled (**SS**) $\times$ long-styled (**ss**) $\rightarrow$ short-styled;

Hetero-short-styled (**Ss**), selfed $\rightarrow$ 3 short-styled : 1 long-styled ;

Hetero-short-styled (**Ss**) $\times$ long-styled (**ss**) $\rightarrow$ 1 short-styled : 1 long-styled.

But in fact the heterozygous short-styled plants when selfed showed a deficiency of short-styled offspring as compared with the expected 3 : 1 ratio, while the same plants crossed with long-styled plants gave an excess of short-styled offspring. The cause of these results has not been explained.¹⁾

Eye of the Flower. As regards the type of eye, there exist the following several varieties in primulas.

1) The small yellow eye of most varieties.

2) The large yellow eye of 'Primrose Queen,' in which the yellow color extends up over about a third of the limb of the petal. The effect of the large yellow eye gives rise, in the absence of the gene **S** for short-style, to the 'homostyle,' i.e., the anthers stand at the lower level and the style instead of projecting into the mouth of the tube stops at the anthers level, being thus practically of the same length as in the short-styled type.

3) The white eye of 'Queen Alexandra,' in which the yellow color is nearly entirely suppressed.

4) Lee's eye of Lee's variety, in which the yellow is only a little less extensive than in 'Primrose Queen,' though the two can be easily

1) In other dimorphic species of *Primula*, the same monohybrid scheme of segregation was also found to hold true for heterostylism. They are *P. acaulis* (GREGORY, 398), *P. malacoides* (UBISCH, 1317) and *P. officinalis* (RAUNKIÄR, 64; DAHLGREN, 435). Recently ERNST (1252) reported that he obtained similar results for *P. vulgaris*, *elatior* and *veris*, *P. auricula* and *P. farinosa*.

In a short-styled plant of *P. hortensis*, ERNST (1252), however, observed an exceptional case which led him to a new interpretation of the heterostylism-inheritance in *Primula*. This plant, when crossed with normal long-styled plants of *P. hortensis* and of *P. hirsuta*, gave offspring consisting of two types in equal numbers, one being normal short-styled, and the other long-styled, but with anthers standing at the level of the stigma. From these and further observations, the author postulated two genes for heterostylism, **A** shortening the style and **B** raising the level of the anthers. The scheme of genes may be represented as:

AB short style with anthers at the higher level (normal short-style),

Ab short style with anthers at the lower level (short homostyle),

aB long style with anthers at the higher level (long homostyle),

ab long style with anthers at the lower level (normal long-style).

The two pairs of genes, **Aa** and **Bb**, are closely linked in combination, thus the normal short-styled form is **Ab aB** and the normal long-styled form **ab ab**. The original short-styled *hortensis* was assumed to be **AB aB**.

distinguished by the position of the stigma, which is normal in Lee's but below the anthers in 'Primrose Queen'.

BATESON & GREGORY (46) and the latter author alone (171) showed that the normal small eye is dominant to the large eye, giving a monohybrid ratio in F_2 , and that the white eye acts in varying degrees as a dominant over both the small and the large eyes. Thus these three types form a series of multiple allelomorphs.

The genetical relations of Lee's eye to other types were determined by GREGORY, DE WINTON & BATESON (1012). According to them, Lee's eye is recessive to the white eye, but is dominant to the large eye. The authors also observed that there are certain relations between the eye and crimping of the leaves, as follows :

- 1) The normal eye is never combined with the fully crimped leaf.
- 2) The 'Primrose Queen' eye is compatible with the flat leaf, but Lee's eye is not.

The cross, flat large $\times$ crimped Lee, gave in F_1 normal eye, flat leaf and in F_2 four types : flat normal, flat large, crimped Lee and crimped large in a dihybrid 9 : 3 : 3 : 1 ratio. From these results, they inferred that Lee's eye is genetically identical with the normal eye, but it is modified when combined with the crimped leaf.

Doubleness of Flowers. Two types of the doubling of flowers are known in *P. sinensis*, and genetically studied.

- 1) 'Common double.' In this, the supernumerary segments are inserted at the throat of the tube, one segment occurring opposite each petal. The anthers are somewhat exsert, and are attached at the base of the supernumerary segment. The cross, double $\times$ single, gave single in F_1 , and showed normal segregation. GREGORY (171).

- 2) 'Old-fashioned double.' The doubling is more complete than in the previous one, and a number of supernumerary segments occupy the center of the flower. The stamens are entirely replaced by the petals, and the stigma, if present, is considerably deformed. When the deformity was extensive, flowers produced no seed. This imbricate type of doubling behaves as a recessive, a single gene being concerned. GREGORY, DE WINTON & BATESON (1012).

Shape of the Corolla. The typical *P. sinensis* has the ordinary, imbricated corolla lobes, while the '*stellata*' variety has the corolla of the 'star' type in which the corolla lobes are non-crenated and heart-shaped.

GREGORY (171) showed that the hybrid between these two types is intermediate (known as the '*pyramidalis*' form). In F_2 *sinensis*, inter-

mediates and *stellata* forms were obtained. Grouping the first two into one — for it was not easy to distinguish the intermediate forms from the true *sinensis* type —, GREGORY obtained a monogenic ratio of 3 (*sinensis* + intermediates): 1 *stellata*.

Form of the Leaf. There is a considerable range of variation in the form of the leaf in this plant.

‘Palm’ is the normal palmatifid shape.

‘Fern’ is the pinnatifid shape, and much reduced in the width of the leaf.

‘Oak’ is a form in which the lobes and serrations are much fewer than those of the normal palm, and each lobe is separated by a deep sinus which nearly extends to the midrib.

‘Crimped’ is a form whose margin is enormously increased in length and crimped.

Results of crossing (GREGORY, 171; GREGORY *et al*, 1012) indicate that the normal flat palm acts as the most epistatic character to the other forms. Fern and oak gave palm in F_1 , and in F_2 a certain proportion of the combination fern-oak. Flat oak $\times$ crimped palm gave in F_2 the combination crimped oak. Thus, concerning the number of lobes only, the small number in palm is dominant to the large number in fern, but a still smaller number in oak is recessive to the large number in palm.

Another curious form ‘ivy’, described by GREGORY (171), is palmate, but having a smooth, undivided leaf-margin. This peculiarity of the leaves is always accompanied by abnormal development of the flowers, which are very much reduced. This type proved to be a simple recessive to palmate. When ivy is crossed with fern, the F_1 plants are palmate, and in F_2 a dihybrid ratio of 9 palmate: 3 fern: 3 palmate-ivy: 1 fern-ivy is obtained. Thus, as regards the character of crenation only, crenate is a simple dominant to non-crenate.

From these results it is clear that these leaf-forms are governed by four pairs of genes, of which none are linked to each other.

Habit of Growth. KEEBLE (253) published a paper on the genetics of gigantism in *P. sinensis*. In one cross of giant $\times$ normal, he obtained in F_2 66 non-giants to 1 giant, which suggests three genes for gigantism. On the other hand, there are strains of the gigas type which are absolutely sterile when crossed with all varieties of *P. sinensis*. Such plants were found to be tetraploid, owing to the doubling of the ordinary chromosomes (GREGORY, 343).

*Linkage Relations.*¹⁾ GREGORY (170, 171) and ALTENBURG (427, 752) made some observations on linkage in *Primula*. Later, GREGORY, DE WINTON & BATESON (1012) gave a full account on this subject, and identified two linkage groups. The first group contains the following four pairs of genes:

- S-s**: short—long style,
B-b: blue—non-blue flower,
G-g: green—red stigma,
L-l: light reddish—deep red stem.

The gene **R**, causing red flowers, is probably not included in this linkage group. The system is characterized by one remarkable peculiarity, which has not been observed in other plants. The percentage of crossing over differs greatly in the macro- and microgametes of the same plants, as represented by the following table:

		Percentage of crossovers	
		♀	♂
S-B		7.5	12.5
S-G		33.3	40.0
S-L		37.0	40.7
B-G		31.25	34.5
B-L		35.6	37.0
G-L		3.2	1.8

The linkage of **S** with **B** is closer on the female side, whereas that between **G** and **L** is closer on the male side. These values, whether as coupling or as repulsion, are the same.

The second linkage group consists of two pairs of genes, as follows:

- F-f**: flat—crimped leaf,
Ch-ch: *sinensis*—*stellata* flower.

The observed crossover percentage is 10.4. This value is the same on both the male and female sides.

Prunus Amygdalus

Color of Fruit-flesh. According to CONNERS (683), the white-fleshed peach (e.g. Greensboro) seems to be dominant to pure yellow (e.g. Early Crawford). The correlation of green calyx cup with white-fleshed fruit and of orange calyx cup with white-fleshed fruit was observed. Further he found an intermediate type in which the calyx cup is yellowish buff

1) The haploid chromosome number in *Primula sinensis* is 12. (Vide TISCHLER, *loc. cit.*)

and the fruit white-fleshed, but this variety proved to carry a character for yellow flesh. A correlation was also observed between the dark green leaves and white-fleshed fruits and between normally yellowish leaves and yellow-fleshed fruit.

Taste of Fruit. HEPPNER (1022) mentions that sweetness seems to be a simple dominant to bitterness.

Surface of Fruit. According to BECKER (983), the cross, nectarine $\times$ peach gave peach; nectarine $\times$ nectarine gave nectarine only. Thus woolliness is dominant; smoothness, recessive.

Foliar Gland. CONNERS (771) observed three types of leaves, namely, those without glands, those with globose, and those with reniform glands, the last being much more numerous. A correlation was noted between the type of gland and the character of the margin, reniform glands being correlated with crenate margins, and globose glands with serrate-crenate margins. Reniform $\times$ globose and the reciprocal combination yielded seedlings in the approximate ratio of 1:1 in respect to glands. Glandless seedlings resulted only from the offspring of globose-glanded varieties.

Flower Size. CONNERS (683) made crosses between small- and large-flowered varieties. F_1 seedlings had medium-sized flowers, which showed segregation in F_2 in a certain ratio.

Prunus domestica

BEACH & MANEY (218), dealing with three varieties of *Prunus*, the Wyant plum, the sandcherry and the Montmorency cherry, made some observations on the inheritance of several morphological and physiological characters. The following is an abstract of their work.

Color of Foliage. The sandcherry is characterized by a rather pale green foliage, the Montmorency cherry has a dark green leaf. The Wyant plum has also a dark green leaf. Crosses between these varieties showed that the sandcherry color is either dominant or imperfectly dominant to the cherry color, while the plum color is either dominant or imperfectly dominant to the sandcherry color. Thus the leaf color of Montmorency is genotypically different from that of Wyant.

Form of the Leaf. 1) Base of the leaf. The base of the sandcherry leaf is different from that of either the Montmorency or the Wyant. It is narrow, and makes an acute angle with the petiole, while that of the Montmorency is round and blunt, and that of the Wyant varies from roundish to a nearly 60° angle. Crossing experiments showed no Mendelian segregation.

2) Type of the leaf. The leaf of Montmorency is characterized by a broad limb with tapering tip, as also is that of Wyant, but the sandcherry leaf is narrow with a rather obtuse tip. The former type is imperfectly dominant to the latter.

3) Serration. The serration in the sandcherry is simple and obtuse, while that in the Wyant is sharply acute and often double. The former is dominant or imperfectly dominant.

4) Ratio of length to width. The sandcherry has a long and comparatively narrow leaf. The Wyant plum has a long but broad leaf. The former is a simple recessive character to the latter.

Stipules. In the Montmorency the stipules are early deciduous, while in the sandcherry they are persistent. The character of persistent stipules is a simple recessive.

Habit of Tree. The low stature of the sandcherry appears to be a simple recessive to the high stature of the cherry and plum.

Aphis Resistance. The character of immunity to attacks by *Aphis* proved to be Mendelian. Susceptibility is transmitted by both Montmorency and Wyant as a simple recessive, immunity of the sandcherry being dominant.

Self-sterility. With respect to self-sterility in the plum, DORSEY (616) report that there are some evidences indicating that self-sterility is a simple unit character, self-fertility being recessive.

On the other hand, SUTTON (588) and CRANE (1244) state that the property of self-sterility may be a Mendelian recessive, yet it seems probable that more than one gene is involved. CRANE found further that certain varieties of the plum, in addition to being self-sterile or rarely partially self-fertile, failed to form fruit when pollinated with other distinct varieties. Four groups of such incompatibles were found. According to CRANE's opinion, although self-sterility and cross-incompatibility appears to be closely associated, nevertheless some evidences exist showing that they are determined independently. For these reasons, he assumed two sorts of genes: **F** = a gene conferring self-fertility, and **A, B, C** and **D** = genes for each kind of incompatibility of Groups I, II, III and IV respectively. Thus:

Group I = **fAbcd**,

Group II = **faBcd**,

Group III = **fabCd**,

Group IV = **fabcD**.

A-carrying stigma is incompatible with A-carrying pollen, B-carrying stigma incompatible with B-carrying pollen, and so on. In three of these groups, however, varieties were found which fail to be fertile only when they are used as females. These varieties were considered as heterozygotes for incompatibility. The ffAa plants would inhibit A pollen, but its pollen grains possessing the segregated a would not be excluded by the stigma of the other members in Group I. Nevertheless, ffAa plants are self-sterile owing to the absence of F.

Ranunculus arvensis

As regards fruit surface, there are three varieties of *Ranunculus arvensis*: spiny, tuberculated and smooth. BATESON & PUNNETT (47) showed that the spiny type is a simple dominant to the smooth (also DE VRIES, 56). The cross, tuberculated $\times$ smooth, was found to give F₁ partially spiny.

Raphanus

Root Color. MALINOWSKI (454) made crosses between two varieties of *Raphanus sativus*, and showed that yellow is a simple dominant to white. TROUARD-RIOLLE (472, 747) studied the F₁ generations from reciprocal crosses between *R. sativus* and *R. raphanistrum*. As to character of anthocyanin, he divided radishes into three groups: rose or red; violet; and black, gray or white. Crosses between red on one side and black, gray, yellow (this is a heterozygous form) or violet on the other, all were found to give violet in F₁. FROST (1005) found also that the red-rooted wild plants crossed with the white cultivated plants gave F₁ plants having purple or violet-pink roots.

UPHOF (1223) worked at several varieties of summer radishes, and found a clear monogenic difference between red and white, the heterozygote being purple (in crosses, Long Red $\times$ Icele, Early Red $\times$ Early White, Long Red $\times$ Early White) and between yellow and white (in crosses, Round Yellow $\times$ Round White, Early White and Icele). An exceptional case was observed in the cross between white-rooted Icele and red-rooted French breakfast, in which the F₂ progeny contained, in addition to the expected parental types and purple heterozygotes, a small percentage of pink-rooted plants. It was also found that the red striping of the variety Triumph is dominant to white (Early White and Icele). But the F₂ ratio of red-striped: white was proved to be 1:1, instead of 3:1. The author suggests the possible

presence of a gametic lethal. UPHOF also made some interesting observations on the commercial variety, Long White. Some seedlings of this variety were found to have red primary-cortex cells, while others had white. The pigment can be detected only in the early seedling stage, and as the root becomes fleshy the red color disappears. In reciprocal crosses between red and white, all the F_1 plants showed roots with a reddish primary cortex. In F_2 , a 15:1 ratio was obtained, indicating that the pigment is due to two duplicate genes, R_1 and R_2 . This dihybrid scheme was confirmed in F_3 .

Other Characters. FROST (1005) made some observations on flower color. Crosses with purple, red and white indicated that red is the most epistatic color, and purple is dominant to white.¹⁾

As to texture of capsules, FROST showed that the woody capsule of the wild species is dominant in F_1 to the papery capsule of the cultivated species.

In the same paper, he also reported that in general, an early-flowering (cultivated) type uniformly prevailed in F_1 over a late-flowering (wild) type.

With respect to root form, MALINOWSKI (454), from a cross between two cultivated varieties, Eiszapfen (long) and Wiener (round), found that the long form is due to two partially dominant genes, which are absent from the recessive round form. UPHOF (1223), however, showed a monogenic difference in all crosses where different root forms were concerned. The heterozygote was intermediate between the two homozygous parents, and in F_2 a 1:2:1 ratio was always obtained. This is the case, for example, flattened round-rooted Triumph $\times$ long Icicle, round Early White $\times$ long Long Red, etc.

The same monohybrid scheme was shown by the same author to be true in regard to length of foliage.

UPHOF also described crosses between the Black Winter radishes and ordinary summer varieties. The former is characterized by the presence of a corky tissue around the periphery of the roots. This character was always dominant to its absence, a characteristic of the summer radishes.

The roots of *R. sativus* contain sugar, while roots of wild plants have

1) TSCHERMAK (475) also studying *raphanistrum-sativus* hybrids found the violet or reddish color of the latter dominant to the yellow of the former. The character showed mosaic inheritance in F_2 ; some branches of the heterozygote had yellow flowers, while the other of the same plant violet flowers, sometimes a single red- and yellow-colored flower appeared.

no sugar. According to TROUARD-RIOLLE (472, 747), F_1 plants contain less sugar than the cultivated forms. The presence of starch in the root, a characteristic of the wild radish, proved also dominant in crosses.

*Linkage Relations.*¹⁾ A case of linkage has been reported by FROST (1905) between two genes, one being the gene originating the reddish pigment in the roots, the other being that responsible for the fleshiness of the roots (which is probably in correlation with the lateness of flowering time). It was preliminarily stated that these genes gave only 4.78 per cent of crossovers, but the data were very insufficient.

Reseda odorata

COMPTON (1923) showed that orange-red color in the pollen is dominant to bright yellow; self-fertilized heterozygotes throw about three reds to one yellow.

In the same and also in a later publication (1929), COMPTON found the difference between self-fertility and self-sterility to be monogenic, the former being dominant.

Rhododendron

MIYAZAWA (1940), working at several varietal crosses of *Rhododendron indicum* var. *obtusum*, as well as specific crosses between *R. indicum* and *R. sinense*, found the following facts:

- 1) Upright stem is dominant to herizontal.
- 2) Leaf-breadth and size of flower are intermediate in F_1 between the two parents.
- 3) Singleness of flower is dominant to doubleness, the difference being governed by a single gene.
- 4) Self-colored flowers are dominant to variegated.
- 5) Short stamens are dominant to long.

Later IKENO (1927) published his work on the inheritance of three abnormal flowers in *Rhododendron*.

1) Calycanthema or 'horse-in-hose'. The hose-in-hose plants, found in *R. indicum* var. *Kaempferi*, are marked by female sterility, due to the abortive pistil, but they produce functional pollen. When crossed with the normal-flowering type, two parental types were again obtained. The normal F_1 plants, when crossed *inter se*—since they were self-sterile

1) The haploid chromosome number in *Raphanus sativus* and *R. raphanistrum* is 9. (Vide TISCHLER, loc. cit.)

—gave only normal plants. From these results it was assumed that the hose-in-hose plants are always dominant heterozygotes with the constitution **Aa**, while the normal plants are pure recessive **aa**.

2) *Apetala*. The apetalous plants are characterized by the replacement of petals into stamens, for there are two whorls of five each. In crosses of these apetalous races with the normal form, three types were produced in F_1 —normal forms, apetalous forms and intermediate apetalous forms. The results were explained on the assumption of two genes, **P** and **R**. The apetalous forms are heterozygous for both the genes, **PpRr**, the normal type is homozygous for the recessive genes, **pprr**, and the intermediate forms are heterozygous for one pair of the genes, **Pprr** or **ppRr**.

3) *Polypetala*. The polypetalous race was found in *R. indicum* var. *macranthum*. This type is characterized by a complete separation of the corolla lobes and a complete abortion of the anthers. By crossing the polypetalous with the normal sympetalous, it was shown to be heterozygous for a single gene which is absent from the sympetalous plants.

Richardia

RAGIONIÉRI (652) made certain observations on a specific cross, *R. Rehmannii* $\times$ *R. Elliottiana*. The characters differentiating these two species were as follows:

	<i>R. Rehmannii</i>	<i>R. Elliottiana</i>
1) Size of tubers:	Small,	Large.
2) Shape of leaves:	Narrow, lanceolate,	Broad, hastate.
3) Length of petioles:	Short,	Long.
4) Markings on leaves:	Few, small, whitish-green, linear markings,	Numerous whitish blotches.
5) Form of spathes:	Small, short-stalked, nearly closed,	Large, long-stalked, well-opened.
6) Color of spathes:	Light rosy-violet,	Yellow.

The characteristics of *R. Elliottiana* were dominant in F_1 , except for the yellow spathe color which was almost recessive. The hybrids bore pale cream and rosy-violet spathes. In F_2 these characters showed segregation. Some plants had large, well-opened spathes of various colors, such as rosy-violet, purple, orange-yellow and yellow-shaded violet. The leaves showed a range of variation in shape and size. In some plants the leaves were uniformly green without any markings on

them. The number of plants raised in F_2 , however were too few to make it possible to carry out a complete analysis of the genes involved in these characters.

Ricinus communis

Stem Color. WHITE (594, 595) described several varieties of stem coloration. According to his observations, stem color in castor beans can be roughly classified into five categories: (1) bright green, (2) green with reddish blush on sunny side, (3) carmine or rose red, (4) mahogany and (5) purple or dark red. An intimate correlation was found between stem color and color in other parts of the plant. The mahogany-red-stemmed plants have mahogany red leaves and fruits. The rose- and red-blush-stemmed types have green leaves with red or reddish midribs. The dark purplish-red(mahogany bloom)-stemmed plants have dark purplish-red leaves and fruits. The author, from his experiments, established the following three allelomorphs: (1) red-blush and green, (2) red-blush and mahogany, the heterozygote being rose or carmine, and (3) rose and red-blush.

Later, HARLAND (699, 908) published his data, and confirmed the allelomorph, red-blush and mahogany. The cross was also made between green and mahogany. The F_1 plants of this cross were rose-stemmed. In F_2 several types were obtained: green, mahogany, several shades of rose, grading down to red-blush, and a new type, called 'tinged.' In the last form, the young leaves are strongly reddened, but the color gradually disappears, so that old leaves are practically green; the glands on the leaf-stalk retain their color, and a faint tinge of color is seen in the stem. Grouping the F_2 plants into (a) rose and tinged—owing to difficulty of distinguishing some of the paler types of red-blush and tinged—, (b) mahogany and (c) green, the author obtained a dihybrid ratio of 10 (a) : 3 (b) : 3 (c). Through the F_3 analysis and back-crosses, the author postulated two genes, **M** and **G**, their combinations being as follows:

MG		rose,
Mg		mahogany,
mG		green,
mg		tinged.

Seed Coat Color and Pattern. There are a number of varieties as to seed coat coloration. WHITE (595) made some observations on the inheritance of this character, and showed that chocolate brown is the color

most epistatic to other colors, such as black, red, gray and white. The cross, red $\times$ brownish gray, and its reciprocal, gave in F_1 brown on a gray background and in F_2 brownish gray and reddish gray approximately in the 3:1 ratio. No reds as brilliant as the grandparental type appeared, showing that more than a single gene was involved. He also described three types of mottling: coarse, fine and large splotched. Crossing experiments showed that the fine-veined type is dominant to the coarse type, which is in turn dominant to the large-splotched type. No F_2 progeny has been grown.

Bloom. Varieties of *Ricinus* are also distinguished by the presence or absence on the plant body of a waxy bloom. According to the observations of HARLAND (699), there exist two main types of bloom, one having bloom on the stem, petioles and capsules, and the other having bloom on these parts and also on the under-surface of the leaf.

WHITE (595) recognized the allelomorph, bloom and no-bloom, the F_1 plants having complete or partial bloom. A similar result was obtained by HARLAND (699, 908) who used the former type of bloom in his experiments. The gene was designated as **B**.

TABLE XXXIV.—A SUMMARY OF INHERITANCE OF SOME CHARACTERS IN *Ricinus communis*.

Contrasted characters	F ₁	F ₂	Authors
Dehiscent ('poppers')—indehiscent ('non poppers') pods	Dehiscent	9 dehiscent : 7 indehiscent	WHITE (594)
Two genes, A and B , were assumed.			
Spiny—spineless capsules	Partially spiny	3 spiny : 1 spineless, or 1 spiny : 2 intermediate: 1 spineless	{ HARLAND (699) KÔKETU (1042)
A genes, S , was assumed.			
Oval—orbicular seeds	Oval	9 oval : 7 orbicular	{ WHITE (594)
Long—small seeds	Intermediate	Continuous gradations	
Dwarf—tall stature	Intermediate	Segregation into the 3 types	
The dwarf plants are early in seed-maturing, and show determinate growth, while the tall plants are late and indeterminate.			
Crinkled—normal leaf	Normal or intermediate	—————	{ WHITE (594)
Loose, few seeded—dense, compact spike	Loose or intermediate	—————	

Other Characters. The above table (TABLE XXXIV) presents a summary of results on the inheritance of some morphological characters in *R. communis*.

*Linkage Relations.*¹⁾ The two genes, **B** determining the waxy covering of the vegetative organs and **M** producing the mahogany red, were found to be linked, giving a crossing over percentage of 8.3. HARLAND (699, 908).

Rubus

The purple raspberry, *Rubus neglectus*, was believed to be a natural hybrid between *R. strigosus* and *R. occidentalis*. This was experimentally proved by WELLINGTON (321), ANTHONY & HEDRICK (428). For the greater part of our data on the inheritance of characters in the raspberry we owe to these experimentors.

Fruit Color. (WELLINGTON). Selfed Columbian, a purple variety, gave 31 purple, 7 red wine, 2 red (?), 1 yellow and 1 black. The two reds, after the fruit became old, turned to a purple color. As to the fruit color, the following results were also obtained:

Black (Smith No. 1) and red (Louboro) gave purple.

Black (Smith No. 1) and red (June) gave purple and black in a proportion of 1:1 (50 purple:46 black).

(ANTHONY & HEDRICK). Red × Red gave 181 red and 7 yellow. The crosses were June × Cuthbert, Marlboro × June, and selfed Helbert.

It seems that purple is the most epistatic color, and red is dominant to yellow, and several of the black varieties are heterozygous as to color.

Stem Color. (WELLINGTON). Columbian, a purple-caned variety, when selfed, gave 29 purple, 19 brownish red and 2 green or colorless. The green canes are evidently recessives, the purple dominants, and the brownish red intermediates.

Bloom. (WELLINGTON). The Columbian variety which possesses glaucous canes, gave on selfing 10 glaucous, 26 having a medium amount and 14 non-glaucous. Then we have the glaucous plants to non-glaucous ones in an approximate 3:1 ratio.

(ANTHONY & HEDRICK). A similar monohybrid ratio was obtained in the F_1 hybrids from Cumberland by June, and Smith No. 1 by June.

Stem Surface. (ANTHONY & HEDRICK). Many red raspberries have

1) The haploid chromosome number in *Ricinus communis* is 10. (Vide TISCHLER, loc. cit.)

the bark roughened by the exfoliation of some of the outer bark. This is much less noticeable among the black-caps. Cumberland and Smith No. 1 had smooth bark and June less exfoliation than most reds. Crosses between these varieties gave in F_1 a ratio of 3 rough : 1 smooth.

(WELLINGTON). As to spines on the cane, he found that among the Columbian seedlings there were 16 very spiny, 25 intermediate and 9 with very few spines. It was concluded that the inheritance of the number and kind of spines depends on several genes. (ANTHONY & HEDRICK). Analogous results were obtained in Cumberland (with many slight spines) by June (none or only at base) and Smith No. 1 (with numerous strong spines) by June.

Dwarfishness. (ANTHONY & HEDRICK). Among the purple raspberries from Cumberland by June appeared some dwarfs. The dwarf plants were characterized by shortening of the internodes, but had as many nodes as the normal plants. In the entire population there were 46 dwarfs and 178 standards. The dwarfishness was considered to be a simple recessive.

Rudbeckia hirta

BLAKESLEE (756) found two genetically different races with yellow discs in the black eyed susan which typically has purple discs. One of the two yellow races turned black with KOH and NaOH, and was called 'Black Yellow'; the other race gave reddish color with KOH and was called 'Red Yellow.' These two yellows are inherited as simple recessives to the purple color. When 'Black Yellows' are crossed with 'Red Yellows', the F_1 consists of purple plants, and in F_2 a dihybrid ratio of 9 purple : 4 'Red Yellow' : 3 'Black Yellow' is obtained. In these yellow races, the production of reddish pigment is inhibited throughout the plant.

Salix

HERIBERT-NILSSON (550) has published an extensive paper on this genus. Numerous crosses were made between a large number of species, such as *S. viminalis*, *caprea*, *cinerea*, *aurita*, *phylicifolia*, *repens*, *purpurea*, *hastata*, *nigricans*, *daphnoides*, *alba* and *fragilis*. Among these the crosses, *viminalis* × *caprea*, and *viminalis* × *daphnoides*, were raised up to the F_2 generation and investigated in detail. The main results obtained are given below.

Hairiness on Leaves. In crosses of *phylicifolia* (glabrous) with other

pubescent species, *cinerea*, *repens* and *viminialis*, the glabrous condition proved dominant in F_1 . On the contrary, the cross, *viminialis* $\times$ *daphnoides*, the former being pubescent, and the latter glabrous, showed the pubescence to be dominant. The F_2 results from this cross suggested a dihybrid scheme of segregation. Similarly it was also found that the glabrousness of *purpurea* behaves as a dominant when crossed with *caprea*, while the same behaves as a recessive when crossed with *aurita*.

Shape of the Leaf. *S. viminialis* has linear leaves, while in *caprea* they are broadly rounded. The F_1 plants between these two were intermediate as to the leaf-shape, and in F_2 various possible combinations of length and breadth were obtained. Out of the total 157 F_2 plants, the *caprea*-form appeared once only. These results were explained by assuming two polymerous genes, C_1 and C_2 , for the broadness of *caprea*, and a gene, V , for the longness of *viminialis*. C_1 and C_2 have a cumulative effect when acting together, and are heterozygously weakened. These three genes are independently inherited, and consequently the F_2 population includes several new forms, such as *aurita*- and *cinerea*-like forms through the new combinations of the genes. In F_2 of this cross, it was also found that the genes C_1 and C_2 exert peculiar pleiotropic effects upon several other characters, such as mode of growth, leaf-color and periodicity of development. The normal development was shown to depend upon the co-operation of C_1 and C_2 , and where the influence of V is lacking, the C_1c_2 or c_1C_2 plants were characterized by an abnormal periodicity of growth ('Remontierung'). And further the C_1c_2 plants were demonstrated to be different from the c_1C_2 plants in their dwarfish stature and somewhat yellowish leaves.

In the cross, *viminialis* $\times$ *daphnoides*, the former proved to possess a dominant gene for its long leaf-shape, and the latter similarly a gene for broadness of the leaf.

Length of Stigmas. In crosses of *viminialis* having a long stigma with *caprea*, *cinerea* and *aurita* having short stigma, long was found to be dominant. On the contrary, the cross, long *viminialis* $\times$ short *daphnoides*, resulted in the dominance of the shortness.

In F_2 from *viminialis* $\times$ *caprea*, the ratio of long to short was practically 1:1, the numbers obtained being 17 long and 17 short. This unexpected ratio has not been explained.

Pubescence of Capsules. The cross of glabrous *phylicifolia* with pubescent *viminialis* and *cinerea* gave both types in F_1 , in a ratio suggestive of 1:1. The *phylicifolia* parent was regarded as the heterozygote for this character. A peculiar mode of inheritance was revealed in the

viminalis (pubescent)-*daphnoides* (glabrous) cross. In F_1 two types, pubescent and partially pubescent (not pubescent and glabrous) appeared in a 1:1 ratio. The F_2 offspring again consisted of these two forms, and no glabrous plants were obtained.

Other Characters. As to the waxy covering on the stem, the blue waxy condition of *daphnoides* was dominant to the non-waxy of *purpurea*, while in a cross with non-waxy *viminalis*, the character of *daphnoides* proved to be recessive. The latter cross gave in F_2 several gradations of waxy covering.

As to pubescence of filaments, the cross of *viminalis* (glabrous) $\times$ *caprea* (pubescent) gave F_1 plants with hairs at the base of filaments. In F_2 17 plants showing pubescence of several gradations and 2 glabrous plants appeared, suggesting the existence of two duplicate genes.

Segregation was also revealed in the same *viminalis-caprea* cross, as to form of catkins, flowering time, leaf-shooting time, resistance to *Melampsora Salicis*, surface-characters of the bark, etc. But the numbers of plants raised in F_2 were too few to permit of a complete analysis of the genes possible.

IKENO (551, 916) dealt with several other species of *Salix*. Chiefly the cross between *S. multinervis* and *S. gracilistyla* was studied in detail. These two species are differentiated from each other in habit of stem, hairiness of leaves, the presence or absence of stipules, color of stigmas, and character of catkins. The results observed up to F_2 may be summarized as follows:

Habit of Growth. *S. gracilistyla* has spreading stem and branches, while in *multinervis* they are erect. The F_1 plants show the spreading type of growth during their early stage of development, but later the plant may produce erect branches, thus assuming an appearance intermediate between those of the two parents. In F_2 , out of 442 total plants, 224 were spreading and 218 erect, the proportion not admitting of the ordinary Mendelian explanation. The fact that the erect habit is a pure recessive character to the spreading was also proved in a cross between an extract erect F_2 plant and the original erect parent, which gave the erect offspring only.

Hairiness of Leaves. The *multinervis* plant has glabrous leaves, while in *gracilistyla* the under-surface of the leaves is more or less densely covered with long gray hairs. The character of *multinervis* was found to be dominant in F_1 . Segregation into these two types was observed in F_2 , but in a ratio differing widely from that expected, the actual proportion being 351 glabrous and 74 pubescent. Among the latter group,

however, various degrees of pubescence were observed, suggesting that a large number of genes are concerned in the hair-production.¹⁾

Stipules. *S. gracilistyla* is characterized by the presence of stipules, while *multinervis* by their absence. The F_1 plants showed a sort of mosaic with respect to this character. The same plant, sometimes even the same branch, bore both leaves without stipules and also leaves with fairly well developed stipules. In F_2 two types appeared, one being provided both with stipulate and exstipulate leaves, and the other having all leaves exstipulate entirely. The actual numbers were 170 and 62 respectively.

Color of Stigmas. In the F_1 the stigma was acarlet, thus indicating that the character of *multinervis* is dominant to the green stigma of *gracilistyla*. In F_2 112 red (of which 7 were greenish-red) and 16 green were obtained. In this case, too, the segregation did not conform to the ordinary Mendelian rules, the ratio of red and green being equal to 8:1.

Character of Catkins. In *gracilistyla* the catkin is long and very densely covered with long gray hairs, whereas in *multinervis* it is shorter and has few hairs. The F_1 plants had two catkin types resembling one or the other parent, namely G(=*gracilistyla*) type and M(=*multinervis*) type. The actual numbers were 70 G and 14 M. It was further found that the cross of G $\times$ G gave rise to many G and few M, and M $\times$ M gave many M and few G, whilst from M $\times$ G approximate equality of G and M types was secured in the offspring. In two of these matings (M $\times$ M, M $\times$ G) a new type of catkin appeared, which is characterized by the entire absence of hairs. Putting together the results of these three crosses, an approximate ratio of 3G:1M was obtained, though the recessives showed a marked positive deviation from the theoretical ratio. Moreover both parents were found to breed true for catkin type in one generation tested. Several hypotheses were postulated. Of these the most probable explanation was the hypothesis of the imperfection of dominance of the gene G for *gracilistyla* in relation to the recessive gene. In the heterozygote the dominance fails, partly resulting in the production of M type plants. Thus the occurrence of the two types of catkins in F_1 is not due to segregation of the genes, but these types are genetically equivalent though they are phenotypically different. This hypothesis was confirmed by back-crosses, either Gg $\times$ GG or Gg $\times$ gg.

1) Another cross between *S. multinervis* and *S. viminalis* gave a different result. The latter has leaves very densely covered on the underside with long silvery hairs. In this cross, the hairy condition proved dominant (or strictly speaking intermediate) in F_1 , and out of 76 F_2 plants, 31 were quite glabrous and 45 hairy in various degrees.

Salvia Horminum

SAUNDERS (47) has dealt with three different strains with respect to the color of the flower: violet, pink and white. There was a close correlation between the color of the flowers and that of the bracts of the inflorescence, the bracts being violet, pink or green according as the flowers were violet, pink or white. The inheritance may be represented as:

BR		violet,
bR		pink,
Br	}	 white.
br		

Saponaria ocymoides

MEUNISSIER (567). The cross was made between the type with small, white, sterile flowers and a variety with large, pink flowers. The F_1 plants resembled the latter form, and gave in F_2 , out of 8 plants, 5 pink-flowered, 1 white-flowered, and 2 white-flowered which turned to pink when the flowers opened.

Secale cereale

Since rye is usually cross-pollinated and highly self-sterile, it is not easy to obtain homozygous strains. For this reason few inheritance studies have been made on this plant, as compared with the other small grains.

COLOR INHERITANCE

Grain. RÜMKE (196, 259) has isolated pure races for greenish blue, deep brown and yellow grain. There are also deep blue, light brown and striped grain. These colors are located in the aleurone layer. In crosses between green- and yellow-grained strains, he found green to be dominant, and obtained a monogenic ratio in F_2 . In this case a regular occurrence of xenia was observed in the yellow-grained mother plants of the cross, yellow $\times$ green, expressing itself in a darker yellowish green tinge on the otherwise pure yellow grains. A similar observation was made also by TSCHERMAK (65).

STEGELICH & PIEPER (961) found also that green (the presence of bluish pigment in the aleurone cells) is a simple dominant to yellow (the absence of the pigment). Black color of the epidermis was likewise

dominant to its absence, and is inherited independently of the color in the aleurone layer. Cases of xenia were also observed in crosses, yellow ♀ × black ♂ and green ♀ × black ♂, in which a blackening of the epidermis of the yellow or green grains of the mother plants appeared.

TREBOUX (1316) made some observations on yellow grains. The heterozygous grains were often found to have 2 or 3 bluish green cells scattered in the otherwise yellow aleurone layer. The homozygotic grains can be distinguished when the yellow is associated with the absence of anthocyanin throughout the plant. Using such plants as parents, more clear cut Mendelian ratios were obtained than those reported by other investigators.

Auricle. TSCHERMAK (1006). The red auricle, a characteristic of wild rye, *S. montanum*, is dominant to the green of cultivated forms, *S. cereale*.

SPIKE AND GRAIN CHARACTERS

Spike. TSCHERMAK (65) made the cross between two spike-types of rye, one having short and broad ears (Heinrich rye), and the other long and narrow ears (as in Hanna-Schlanstedter, Probsteier and Sächsischem Standen rye). The F_1 plants showed an intermediate condition for this character, and in F_2 a 1:2:1 ratio was obtained. A similar mode of inheritance was also shown in the characters, lax *versus* dense form and erect *versus* hanging form.

In crosses between wild and cultivated ryes, the author also found brittle rachis, firmly closed and hard glumes of the former form dominant to resistant rachis, loose and soft glumes of the latter respectively.

Grain. In the same paper, TSCHERMAK observed a monogenic segregation in F_2 of the cross between long- and short-grained strains, the F_1 hybrids being intermediate in the length of grains. But in this case some of the intermediates proved constant, indicating that several genes are involved in this character.

OTHER MORPHOLOGICAL CHARACTERS

Length and Diameter of Culm. In crosses of the short-culmed Heinrich rye with the relatively long-culmed Petkuser rye, TSCHERMAK (65) found the F_1 plants intermediate in culm-length, and obtained a range of variations in F_2 , in which the shortness of culm was associated with the shortness of spike.

As to the diameter of culm, the same author reported that a cross of the wild rye having thin culms with the cultivated rye having thick culms gave in F_1 an intermediate condition, showing segregation in F_2 into three types in a 1 : 2 : 1 ratio.

Pubescence. In crosses of wild with cultivated ryes, TSCHERMAK (65) observed the dominance of the hairy culm and leaf-sheath (of the former) over the glabrous condition (of the latter).

Wax Formation. In the same cross, he also showed that the presence of wax in the stem, leaves and glumes (in the wild rye) is dominant to its absence (in the cultivated rye). A similar result was also obtained by HERIBERT-NILSSON (493) who crossed a non-waxy strain of Brattingsborg rye with the normal waxy type of Petkuser rye. In F_2 a monohybrid segregation was shown.

Chlorophyll Deficiencies. According to NILSSON-EHLE (306), yellow and white seedlings are simple recessives to the normal green. A similar observation was made for white seedlings by KALT (451).

PHYSIOLOGICAL CHARACTERS

Self-sterility. HERIBERT-NILSSON (493) found high self-sterility to be dominant to self-fertility and due to a single gene. However the production of constant forms of intermediate self-sterility indicated that several genes are concerned in this character.

BREWBAKER (988), on the other hand, briefly noted that he obtained results unexplainable on any simple genic basis for this character.

Resistance to Rust. According to MAINS & LEIGHTY (1053), resistibility to leaf rust (*Puccinia dispersa*) is probably dominant to susceptibility to the same, however the appearance of intermediate types is considered to indicate the existence of several genes.

Vegetative Habit. TSCHERMAK (65) obtained the following results :

- 1) The spring habit appears to be a dominant character to the winter habit, the F_1 plants being intermediate but nearer to the spring form and showing segregation in F_2 in a ratio of 3 springs to 1 winter.

- 2) Earliness in maturing prevails in F_1 over lateness; the F_2 segregation indicates that several genes are involved in this character.

- 3) Lateness in germinating (wild rye) and earliness (cultivated rye) give an intermediate F_1 .

- 4) The perennial habit (wild rye) behaves as a dominant to the annual or biennial habit (cultivated rye).

WHEAT-RYE HYBRIDS

Crosses between wheat and rye have been reported by a number of investigators: BACKHOUSE (481), GAINES & STEVENSON (898), JESENKO (179, 300), LEIGHTY (413), LOVE & CRAIG (647), McFADDEN (506) and others. In nearly all cases, wheat has been used as the female parent, with an exception reported by GAINES & STEVENSON who obtained the first successful rye ♀-wheat ♂ hybrids. As a rule the F_1 plants are intermediate in general characters, and are highly self-sterile, although back-crosses with the parents have sometimes been successful. LOVE & CRAIG continued the hybrids up to F_4 and F_5 , and obtained a number of plants which exhibit little or no sterility.

For a few particular characters, JESENKO was able to get close approximation to a Mendelian analysis:

1) Awnlessness of Bielers Epp wheat is dominant to awnedness of Petkuser rye, giving a 3 : 1 ratio in F_2 .

2) Pubescence of the leaf-sheath is dominant to glabrousness. Crosses between two glabrous plants, Mold Squarehead × Petkuser rye, gave pubescent F_1 , indicating that pubescence is due to two complementary genes.

Senecio vulgaris

TROW (267) published results of crossing a number of elementary species of *Senecio vulgaris*, such as Praecox, Erectus, Multicaulis, Latifolius, Genevensis, Erectus radiatus, Lanuginosus, Cardiff Groundsel, etc. In this publication the author assumed the following nine pairs of allelogenes:

- 1) **R-r**: radiate—non-radiate flower.
- 2) **C-c**: yellow—cream flower.
- 3) **X-x**: genes determining the development of cream color, **X** inhibiting it and **x** having no effect, as shown by the following scheme: **XC**, **Xc** or **xC**=yellow, **xc**=cream.
- 4) **F-f**: normal—fimbriate rays.
- 5) **H-h**: hairy—glabrous.
- 6) **Y-y**: modifiers of **H**, **Y** depressing hairiness, **y** allowing its full development.
- 7) **Z-z** (?): genes affecting the stimulation of **H** by **R**, **Z** reducing hairiness in **RH** plants, **z** allowing normal hairiness.
- 8) **G-g**: red—green stem.
- 9) **L-l**: dark green—yellow green leaf.

In a later paper (473), Trow made some observations on the inheritance of the number of nodes. In the various pure strains investigated, the nodal number was found to belong to one of the following three main groups:

- 1st. 'low' forms with 9–15 internodes,
- 2nd. 'medium high' forms with 20–26 internodes,
- 3rd. 'high' forms with 29–37 internodes.

The assumption made to account for the results of crossing varieties with different nodal numbers is that two genes **A** and **B** are concerned so that:

AB medium,
aB low,
Ab high.

It was also found that the low forms are 'early' in time of flowering, the medium forms 'intermediate' and the high forms 'late.'

In still another paper (474), the author also showed that white seedlings found in a certain culture of *S. vulgaris* are double recessives to the normal green forms.

*Linkage Relations.*¹⁾ Trow (267) described a partial linkage between **H** (for hairiness) and **R** (for radiate flower) with a crossing over of 36.6 %. He suggested further the existence of a close linkage between **H** and **G** (for red stem color). Later (473), the same author stated that radiate and hairy types have higher nodal numbers than non-radiate and glabrous types, there being decisive evidence of coupling.

Sesamum indicum

ABÉ (596) published results on this species, and identified the following pairs of allelomorphs:

- 1) Branching—non-branching habit,
- 2) Glandular—non-glandular capsules,
- 3) Bilocular—plurilocular capsules.

As regards the color of seed coat, black proved to be dominant to both brown and white, and brown dominant to white.

Setaria italica

SAITÔ (1072) made some experiments on the inheritance of the following characters in this species:—

1) The haploid chromosome number in *Senecio vulgaris* is 19. (Vide TISCHLER, *loc. cit.*)

Grain Color. As to the color of the grain, *S. italica* furnishes a range of variations, orange, yellow, black, etc. A cross, red $\times$ orange, gave orange F_1 , and in F_2 orange, red and yellow in a dihybrid ratio of 12:3:1, though orange and yellow were often scarcely distinguishable. The results were explained on the assumption of two genes **A** and **B**. **A** originates red, and is hypostatic to **B** which produces orange. The absence of both the genes results in yellow.

Length of Bristles. In this plant, the bristles are found near the lower ends of each grain. Their number for each grain varies from 2 to 9. They are either long or short. This difference was found to be monogenic, the long forms being dominant.

Type of Panicle. The common type has very short branches of the panicle, while one race was found in which each panicle was provided with a number of long conspicuous branches. Crosses between these two forms gave in F_1 the panicle of the latter. In F_2 besides both the parental types there occurred various intermediate forms, on account of which the exact grouping of the plants was difficult. Grouping the F_2 population under ordinary type and one of more or less conspicuous branches, however, a dihybrid 9:7 ratio was obtained. It was suggested that various intermediate forms are chiefly due to various combinations of these two genes.

Silene Armeria

DE VRIES (8, 56) mentions that the presence of pigment in the flowers is dominant to its absence.

CORRENS (1329), from crossing of white (very pale rose) with rose-flowered strains, obtained in F_1 red plants, and in F_2 white, red and rose in a monogenic 1:2:1 ratio. The white and rose segregates proved to remain constant in later generations, while the red segregates repeated the same behavior, indicating that they are always of hybrid nature. These red plants are phenotypically identical with those growing wild, which were found, however, to breed true for the character.

Sinapis alba

According to FRUWIRTH (394), TSCHERMAK found a monogenic difference between brown and yellow seeds, the former being dominant. FRUWIRTH, however, observed more complex segregation from his selection experiments with yellow and brown seeds. Some brown-seeded

plants showed normal segregation, but some yellows were followed by a ratio of 3 yellow : 1 brown. A digenic scheme of inheritance was postulated, but not enough to explain completely the results.

Sisyrinchium angustifolium

MIYAKE & IMAI (818) described two varieties differing in the color distribution of the flower, one being self-colored purple, and the other white with purple center forming an eye-pattern. Crosses between these two forms gave F_1 plants having white flowers with colored eye. The dominance, however, was not complete, the hybrids being easily distinguishable from the white parent by the difference of the area of the eye. In F_2 a 1 : 2 : 1 ratio was obtained.

Solanum etuberosum

SALAMAN (142) published a paper on the inheritance of the wild potato. The following accounts are based on his reports.

Flower Color. The flowers of this potato are self-colored (a very delicate lilac) and the pigment is on the under-surface. Segregation was observed among selfed progenies, in which, out of 20 plants, 14 were self-colored, 3 white with purple tongues in the center of the petal, the color in the tongue being on the upper-surface and 3 pure white. The results were explained on a dihybrid basis. **A** is a gene originating color, its absence resulting in white flowers. **B** is a gene causing, together with **A**, uniform distribution of color on the under-surface, its absence causing distribution of the color on the upper-surface. Thus :

AB		self-colored,
Ab		white with colored tongue,
aB	}	 white.
ab		

Tuber Color. It was found that white-tubered plants gave 13 white, 12 white-tinged and 13 deep purple (black). Purple was considered to be a recessive character and white a simple dominant, though in the domestic varieties, *S. tuberosum*, the reverse is true.

Tuber Shape. The tubers of *S. etuberosum* are round, while the selfed progeny comprised both rounds and longs, and amongst the latter were kidneys. The numbers obtained were 18 round, 14 long. It was assumed that the round form is dominant to the long. In the domestic types, the relation is the reverse.

Eye Character. Plants having shallow eyes in the tuber gave seedlings in which 26 were shallow, 8 deep. Shallow eye is thus a simple dominant, whereas in the domestic variety it is recessive.

Resistance to Disease. Amongst the seedlings some were found immune to the attacks of wart disease. Immunity proved to differ from susceptibility by a single gene, the latter being dominant. In the domestic varieties of potatoes the reverse is the case.

Species-Crosses. According to SALAMAN, PATON crossed *S. etuberosum* with a cultivated variety, and found the dominance of white over colored (purple and red) tubers and also of round over long (kidney and oval) tubers.

SALAMAN made reciprocal crosses between *S. etuberosum* and *S. maglia*, the latter having deep purple tubers. He obtained F_1 plants with white tubers, showing the dominance of the 'white' of *etuberosum*.

Solanum Melongena

BACCARINI (104) obtained several color forms in F_2 of a cross of a white variety with another which produces yellow ripe fruit.

HALSTED (545) postulated two pairs of genes for fruit color, one (**G**) originating green pigments in the pulp, and the other (**P**) purple pigments in the tegument. Accordingly the following four combinations are possible:

- GP purple (green pulp and purple tegument),
- gP pink (white pulp and purple tegument),
- Gp green (green pulp and colorless tegument),
- gp white (white pulp and white tegument).

There is also another form with variegated fruit. When this is crossed with a white-fruited variety the hybrids have slightly variegated fruit, but when it is crossed with a purple-fruited variety the F_1 plants have purple fruit, and in F_2 most plants bear purple fruit and only a few have variegated fruit, showing the latter character to be recessive.

Solanum nigrum

DE VRIES (8, 56). The black color in the berry of the black nightshade behaves as a monogenic dominant to the yellow color of var. *chlorocarpum*.

Solanum tuberosum

COLOR INHERITANCE

Flower. EAST (131) found purple flowers probably dominant to white, and FRUWIRTH (233) lilac flowers dominant to white. MÜLLER (1058), in the cross of blue-violet $\times$ white, found colored flowers monogenically dominant to white.

SALAMAN (260)¹⁾ published more extensive results. Red proved dominant to white, but is dependent on the presence of two genes, **D**, a chromogen gene, and **R**, a reddening gene. A third gene, **P**, is required for purple. The scheme of these genes may be given as:

PRD purple,
pRD red (heliotrope),
PRd tinged white,
 Other combinations. . white.

HERIBERT-NILSSON (293) reports that varieties with light blue flowers (Prince de Galles, Ashleaf), when selfed, gave progeny showing simple monogenic segregation, white being recessive. A variety with violet-blue flowers gave, on selfing, various color-forms: red, violet-blue, reddish, purple, dark and light blue and white. A cross of a white variety (Early rose) with a light blue one (Jaune d'or de Norwege) gave white and colored individuals in about 1:1 ratio, and the class of colored individuals contained not only blue, but also reddish violet plants. When Jaune d'or de Norwege was selfed, it gave pale colored- and white-flowered plants only. It was inferred then that the white-flowered Early rose must possess some cryptomeric genes for flower color.

Tuber. SALAMAN (142, 197) worked with several varieties of potato. According to his observations, the color of the tubers which is either purple or red, is due to the presence of colored sap in the cells of the superficial layers. White tubers have no anthocyanin, and proved to breed true. Red-tubered varieties (Flourball, Reading Russet) gave on selfing red- and white-tubered plants in a 9:7 ratio. A black (dark purple)-tubered variety, Congo, when crossed with Flourball gave in F_1

1) In all varieties of *S. tuberosum*, flower pigment is confined to the upper-surface of petals. In *S. etuberosum*, color develops on the lower-surface only. On the other hand, *S. verrucosum* has both surfaces of petals colored. SALAMAN ascribed these differences in color distribution to the presence or absence of inhibitors.

13 black, 12 red and 4 white. One of these black F_1 plants gave in F_2 73 black, 24 red and 75 white. These results were explained on the assumption that two genes are necessary to produce red—**R**, a reddening gene, and **D**, a developer of pigment—, and a third dominant gene, **P**, is required for purple. Thus the scheme of the genes may be represented as:

PRD purple (black),
PRd white (tinged),
pRD red,
 Other combinations. . white.

Some of these results were confirmed by EAST (131), FRUWIRTH (233) and WILSON (480).

HERIBERT-NILSSON (293) made crosses between a light red-tubered variety (Early rose) and a yellow (white) variety (Jaune d'or de Norwege). In F_1 red and yellow plants appeared in a ratio of 1:1, but in the red class various color grades were found, many of them having blue or dark blue striping. Also plants in which only the eyes were colored were obtained. Crosses between two yellow varieties, Early Puritan $\times$ Jaune d'or, gave, in addition to yellow, 10% plants having blue-black, blue, red or pale red tubers.

MÜLLER (1058) worked with *S. edinense* and a variety of *S. tuberosum*. Both the parents were white-tubered. The former, on selfing, gave 13 colored and 40 white plants, approaching to a 3:13 ratio. The latter proved to breed true. When crossed together, they gave 21 colored and 40 white individuals, the ratio being considered to be 3:5. These results, together with those from other crosses, lead the author to assume that two genes, **G** and **H**, are required for color, and a third dominant gene, **Y**, inhibits their action.

KELLY (1172) described a new type, the Red McCormick variety which has cream (white)-colored tubers with light flushes of carmine in and about the eyes. This variety, when selfed, gave 8 seedling plants with the parental type, 5 with cream, 6 with evenly suffused carmine, 2 of which were rather darker colored. The cross of Red McCormick with cream-tubered varieties of Rural gave the following offspring: 31 of the Red McCormick type, 32 with uniformly distributed light color, 44 with uniformly distributed dark color and 98 with cream color. These results were explained on the assumption of three genes, **B**, **D** and **M**. **B** is the basic gene for color, **D** dilutes it, and **M** with **D** gives the characteristic restriction of color in Red McCormick. The origi-

nal strain of Red McCormick was assumed to be **MmBbDd**, and Rurals **mmbbdd**. Thus the scheme of the genes may be represented as :

MBD Red McCormick,
(M)Bd dark uniformly colored,
mBD light uniformly colored,
(M)b(D) cream.

COLLINS (1119) worked also with a parti-colored variety, King Edward in which the tuber is splashed with pink. This variety was crossed with Magestic which was regarded as a homozygous recessive white. In F_1 both the parental forms were obtained in nearly equal numbers. A parti-colored F_1 seedling proved again to be heterozygous for pigment distribution. It was supposed that the parti-colored pattern depends on a definite dominant gene, and it exists in King Edward in a heterozygous condition, and further that uniformly colored, parti-colored and white forms may constitute a multiple allelomorphic series.

KRANTZ (1282) on the other hand obtained different results with parti-colored varieties which could not be explained by the above schemes. The author suggests that parti-colored tubers are produced by two genes, SALAMAN's **D** and **R**, and uniformly colored tubers contain a third gene, **A**, in addition. Thus **ARD** results in uniformly colored, **aRD** in parti-colored and the other combinations in white tubers.

Flesh of Tubers. FRUWIRTH (233) found yellow flesh dominant to white. HERIBERT-NILSSON (293) showed that some of the varieties with yellow flesh breed true to type, while others show segregation into yellow and white in a 15:1 ratio (the numbers obtained being 172:10 in Ashleaf, 223:14 in Prince de Galles). A cross, constant yellow $\times$ white, however, gave not only yellow but some white, showing that white is not always recessive.

MÜLLER (1058) showed that a colored-fleshed variety, on selfing, gave colored and white offsprings in a ratio of 9:7 (the numbers obtained being 123:99). When crossed with a pure-breeding white variety, it gave in F_1 white-fleshed plants only. It was suggested that the formation of anthocyanin in the flesh is due to the interaction of two genes, **C** and **I**, and the white parents are homozygous for an inhibitory gene, **Z**.

Stem. EAST (131) found the presence of anthocyanin (red) dominant to its absence (green), and obtained a simple monogenic segregation.

SALAMAN (142) noted the inheritance of the quantity of pigment in the stem. A plant with a medium quantity gave seedlings in which the degrees of pigmentation were divided into 'strong', 'medium' and

'weak', and the numbers in each class approached a 1:2:1 ratio respectively.

Later, MÜLLER (1058) has published more extensive results. A variety having the pure green stem gave on selfing colored and colorless seedlings in a 3:13 ratio (the actual numbers being 11:119). Another variety having the colored stem gave a ratio of 27 colored:37 colorless (the actual numbers being 108:138). The cross, colored $\times$ colorless, gave both the parental forms in a ratio of 12 colored:20 colorless (the numbers being 50:93). Three genes, **B**, **D** and **E**, are required for color, and another gene, **X**, inhibits it. Thus the parental varieties are formulated as **BbDDEEXx** and **BbDdEexx** respectively.

Seedling. MÜLLER (1058) mentions that the seedling from the tuber when develops in the sunshine contains more or less anthocyanin. The pigment occurs in either very pale, gradually diminishing shades ('colorless'), or more intensive, never fading, shades ('colored'). A colored variety gave on selfing a monogenic ratio, 3 colored:1 colorless (the numbers being 112:30), while another colored strain showed a trigenic ratio, 63 colored:1 colorless (the numbers being 300:6). When crossed together, they gave a 15:1 ratio in F_1 (the numbers being 299:18). It was assumed that the formation of color in the seedling is due to triplicate genes, **A**₁, **B**₁ and **C**₁. The seedling color proved to be always associated with flower-, stem- and flesh-colors. No exceptional case was found. It was, therefore, supposed that the gene **A** for flower color is identical or closely linked with **A**₁, **B** for stem color with **B**₁, and **C** for flesh color with **C**₁.

OTHER MORPHOLOGICAL CHARCTERS

Habit of Growth. SALAMAN & LESLEY (738) found that the normal 'upright' character behaves as a dominant over the 'prostrate'. Segregation in F_2 and F_3 occurred in a ratio of either 3:1, 15:1 or 63:1, indicating that at least three genes are at work. An anatomical study showed that the 'upright' plants have normal interfascicular xylem, while the 'prostrate' plants are characterized by its weaker development. The authors also described another abnormal habit of growth, the 'procumbent'. This variety is a form intermediate between the 'upright' and the 'prostrate' varieties. Though the 'procumbent' plants exhibit the same structure of the stem as do the 'prostrate', they differ in their phototropic response, for the former type is normal in phototropic sensibility, whilst the latter entirely lacks it. Genetically

the 'procumbent' type is a pure recessive differing by a single gene from the 'upright' but its relation to the 'prostrate' has not yet been elucidated.

Leaf Characters. SALAMAN (142) made a cross between two varieties, Red Fir Apple and Reading Russet. In the former variety, the leaves are relatively small, ovate with sharp apices, peculiarly soft and silky to the touch, and are characterized by a peculiar twist in their axes. The latter variety has a much coarser foliage, the leaves are big, broad, hard and coarse, and have no twist. The F_1 plants examined were intermediate as regards shape and texture of foliage, but resembled more closely the Fir Apple shape, no twist in the leaf axis being observed. As to the shape and texture of the leaf, the F_2 results appeared to indicate the Reading Russet type as recessive, though there was a marked deficiency from the expected ratio. The twist in the leaf occurred in F_2 27 times out of 118, that is practically in the 3:1 ratio. It was also suggested that in the F_2 population the twist in the leaf is definitely linked with the Fir Apple characters of shape and texture, and similarly Reading Russet texture almost completely with Reading Russet shape.

Tuber Shape. Extensive work was done by SALAMAN (142, 197, 260) on the inheritance of shape of tuber. The character was found to depend essentially on the presence or absence of a single gene for length. According to this assumption a tuber may be either homozygous long, heterozygous long or homozygous round. Heterozygous long is the most variable of the three conditions. Varieties with round tubers bred true, giving nothing but round tubers, while varieties with oval tubers produced long, oval and round tubers in their selfed progenies. A similar result was obtained by EAST (131), FRUWIRTH (233) and KRANTZ (925).

HERIBERT-NILSSON (293) described, however, a variety of potato which did not breed true to 'roundness.'

Depth and Size of Eye. The eyes of the potato tuber are described as deep or shallow. According to SALAMAN (142, 197, 260), plants which bear tubers all with deeply incised eyes breed true, and similarly the shallow eyed potato will breed true. The hybrid showed no complete dominance, in which both forms of eyes were found on different tubers. As a rule, however, the deep eye was considered to be a dominant character. An analogous inference was drawn later by HERIBERT-NILSSON (293). EAST (131) stated, however, that he obtained results indicating the shallow eye apparently dominant.

As regards the size of the eye, HERIBERT-NILSSON (293) showed that large and broad forms are dominant to small and round.

PHYSIOLOGICAL CHARACTERS

Male Sterility. SALAMAN (141, 142, 260) and HERIBERT-NILSSON (293) published papers on the sterility of anthers (contabescence) in the potato. The condition proved to be distinctly dominant to fertility. At first SALAMAN believed that its appearance was due to a single gene, but later evidence (SALAMAN & LESLEY, 949) indicated a more complex manner of inheritance. A variety, Edzell blue, which produces normal pollen, was found to be heterozygous on its female side for male sterility.

Resistance to Disease. Observations on the inheritance of resistance to wart disease (*Synchytrium endobioticum*) have been made by several investigators. HERIBERT-NILSSON (293) made crosses of a very susceptible strain (Jaune d'or) with a slightly resistant variety (Up to Date), and obtained in F_1 29% of clearly resistant plants. COLLINS (769) from his F_1 hybrids regarded susceptibility as a dominant character, while ORTON & WEISS (827) found it to be a complete recessive.

SALAMAN & LESLEY (1073) published more extensive results. They found that there are at least four types of immunes: (1) immunes breeding true, (2) those which, on selfing, give 15 immunes to 1 susceptible, (3) those which give 3 immunes to 1 susceptible, and (4) those which give 9 immunes to 7 susceptibles. Three genes were assumed, **X** and **Y** responsible for immunity and **Z** complementary with both **X** and **Y**. The scheme of the genes may be then represented as:

$$\begin{array}{l}
 \text{XYZ} \\
 \text{XyZ} \\
 \text{xYZ}
 \end{array}
 \left. \vphantom{\begin{array}{l} \text{XYZ} \\ \text{XyZ} \\ \text{xYZ} \end{array}} \right\} \text{immune,}$$

$$\begin{array}{l}
 \text{XYz} \\
 \text{Xyz} \\
 \text{xYz} \\
 \text{xyZ} \\
 \text{xyz}
 \end{array}
 \left. \vphantom{\begin{array}{l} \text{XYz} \\ \text{Xyz} \\ \text{xYz} \\ \text{xyZ} \\ \text{xyz} \end{array}} \right\} \text{susceptible.}$$

There were, however, some evidences indicating the presence of inhibitors of these immunity genes, but the relation between them, i.e. the activators on one side and the inhibitors on the other, has not been clearly elucidated. It was also found that amongst immune plants there was no difference of degree in the immunity, while amongst sus-

ceptibles considerable differences in degree of susceptibility appeared to be conferred according to differences of genotype.

Time of Maturity. KRANTZ (925) made a cross between Sir Walter Raleigh and an unnamed variety. Although both parents were late maturing, in F_2 a range of variability was observed, segregates differing by more than 60 days in time of maturity. These results suggest the existence of multiple genes for this character.

Spinacia

NOHARA (1061) made crosses between *Sp. oleracea* and *Sp. spinosa*; in the former, the persistent bractlets covering the fruit are smooth, while in the latter they are horned. The horned condition proved to be dominant, and the F_2 segregation was normal.

Stizolobium

BELLING (160, 219, 325, 326, 327, 328, 381, 382) published papers on the inheritance of several characters of the Velvet bean. He crossed the Florida Velvet bean (*St. deeringianum*) extensively with the Lyon bean (*St. niveum*), a variety introduced from the Philippines, and to a lesser extent with Yokohama (*St. hassjoo*), a Japanese variety, and China Velvet beans (*St. niveum* var.).

The main results obtained may be summed up as follows:

Color Inheritance. As to the inheritance of pigmentation, the following characters have been studied in the Velvet-Lyon crosses.

1) The Velvet bean has purple color on the under-surface of the first pair of simple leaves, on the stems as a mark on the leaf axil, on the wings and standard, and also on the stems and petioles on the side exposed to the sun; while Lyon lacks the pigment. In crosses between these two types, the presence of the purple color proved to be dominant in F_1 and both the types were obtained in F_2 in the normal ratio, only a single gene being involved.

2) As regards the inheritance of mottling on the seed-coat, its presence (in the Velvet bean) proved to be dominant to its absence (in the Lyon bean). In F_2 a ratio of 63:1 was obtained, indicating that at least three genes were at work, each of which alone being responsible for the production of some mottling.

3) As to the inheritance of color of plant hairs, two genes are involved: **D** originating black pubescence all over the plant, and **B** inhibiting it. Thus, the cross of **BD** (Lyon) $\times$ **bd** (Velvet) results in F_2 in 13 whitish to 3 black. (See also under '*Plant Hairs*').

Plant Hairs. In the Velvet bean, the ripe pods are covered with a brownish black tomentum mixed with a few stiff hairs, about 1 mm. or more long, while the Lyon, Yokohama and China beans have fine whitish appressed downy hairs averaging 0.5 mm. in length. The pods of the F_1 hybrids of the Velvet with the Lyon, Yokohama and China, are closely covered with more or less appressed stinging bristles, mostly grayish yellow, but usually with a patch of red at the base of the pod. These bristles are about 1.5 mm. long, and contain a gummy substance in their hollow tips. When one touches them, they pierce the human skin, and cause an irritation lasting several minutes. They are, however, shorter and thinner than those of the wild-growing *St. pruritus* and also sting less.

In F_2 of these crosses, the following chief types of plant hairs were obtained:

- 1) Stinging bristles, like those of the F_1 plants.
- 2) Down. There are several types: fine down (about 0.5 mm.), coarse down (up to about three quarters of 1 mm.) and intermediate between downy and stinging (about 1 mm.).
- 3) Long tomentum. Two types were distinguished, one being like that of the Velvet bean, and the other usually softer and blacker and accompanied with black pubescence on the rest of the plant.
- 4) Short tomentum (less than 0.5 mm.), accompanied by black pubescence over the whole plant.

From the study of F_2 — F_5 , the author assumed three genes, **B**, **C** and **D**. The Velvet bean possesses **C**, but lacks **B** and **D**, while in the Lyon, Yokohama and China, **C** is absent, but **B** and **D** are present. Both **B** and **C** are needed for the production of typical stinging bristles. **D** originates, in the absence of **B**, black tomentum all over the plant. The scheme of the genes may be represented as:

BCD	}	. . .	stinging hairs, whitish plant,
BCd			
BcD	}	. . .	downy hairs, whitish plant,
Bcd			
bCD	. . .	long tomentum, black plant,	
bCd	. . .	long tomentum, whitish plant,	
bcD	. . .	short tomentum, whitish plant,	
bcd	. . .	recessive downy hairs, whitish plant.	

The recessive downy plants have long appressed silky down (up to 1 mm.) on their pods. The actual F_2 proportions, however, were stinging (**BCD**,

BCd) 9, downy (**BeD**) 3, 'Velvet' (**bCd**) 1 and black (**bCD**, **bcD**) 4. The other types, **Bcd** and **bcd**, were obtained in later generations. These results indicated that there is a partial repulsion between **C** and **D**, so that they rarely enter the same gamete.

Semi-sterility. The F_1 plants from each of the crosses, Florida $\times$ Lyon, its reciprocal, Florida $\times$ Yokohama, and Florida $\times$ China, showed semi-sterility, i.e. a half of the pollen and ovules were aborted. In F_2 semi-sterile and normal plants appeared in about equal numbers. These semi-sterile F_2 plants repeated a similar segregation in F_3 , while the fertile plants remained constant. The author explained the results by postulating two genes, **K** present in the Florida bean, and **L** present in the Lyon and Yokohama. When either **K** or **L** is present, normal pollen and ovules are produced, while combinations of **KL** or **kl** in the gametes result in pollen- or ovule-sterility. Thus the semi-sterile F_1 plants are of the constitution **KkLl**, giving in F_2 semi-sterile (2 **KkLl**) and normal (1 **KKll** + 1 **kkLL**) plants in a 1 : 1 ratio.

Other Characters. The Florida bean has short pods, while in the Lyon bean the pods are long. The cross between these gave approximately a 3 (long) : 1 (short) ratio in F_2 , although minor genes for pod length were discovered. In the same cross, the dehiscence proved dominant to the indehiscence. The pods on the F_1 plants burst open when mature, and segregation occurred in F_2 showing a monogenic difference.

In the inheritance of seed length, the F_1 plants bore long seeds, and in F_2 a ratio of 3 long : 1 short was obtained.

Besides these characters, it was also found that time of flowering, size of flower clusters and size of plant gave distinct segregation in F_2 of the cross.

*Linkage Relations.*¹⁾ As already stated, the genes, **C** and **D**, are closely linked together. BELLING (381) also briefly announced some results concerning linkage of semi-sterility with lateness in flowering period and also with pigmentation in the seed coat. The genes responsible for these characters are: **K**, a gene concerned with semi-sterility, **P**, a gene for pigmentation of seed coat and **H**, the main gene for lateness. **K** and **H** were found to be strongly coupled, as also were **P** and **H**; **K** and **P** showed secondary coupling.

1) The chromosome number of these species has not yet been determined.

Tagetes erectus

PUNNETT (1068) published a paper on *Tagetes erectus* (African Marigold). It was found that the single form of flower is a simple recessive to the double, and the tubular form of floret recessive to the flat. The cross, single-tubular $\times$ double-flat, produced a 9 : 3 : 3 : 1 ratio in F_2 .

Some observations were also made on flower color. One of the parents was deep orange; the other was what was recorded as 'orange-yellow, nearer yellow than orange'. The F_1 plants showed an intermediate shade, and in F_2 a graded series of colors from deep orange to pale lemon was obtained. The proportion in which these last appeared was 11 in 221, suggesting that two genes are responsible for the change from lemon yellow to some shade of orange. And there must be other genes which affect the intensity of the color.

Trifolium pratense

Flower Color. DE VRIES (8, 13, 56) found a monogenic difference between red and white, the former dominating. KAJANUS (252) showed that red flower color is probably determined by two genes and dominant to blue and white. Similar observations were made by MAYER-GMELIN (457) and MALTE (814). RAUM (736) mentioned, however, that the mode of inheritance of red vs. white is more complex.

Seed-Coat Color. According to KAJANUS (252) and MALTE (814), dark purplish color is dominant to light purplish and pink, and both dark and light purplish dominant to yellow and brown. RAUM (736) reported, however, that yellow appears to be dominant to purplish.

WITTE (858), on the other hand, found a monogenic difference between yellow and white, the former being dominant.

According to the observations of WITTE, the white seed-coat color seems to be correlated with white flowers and with a lack of anthocyanin in the calyx-teeth and other vegetative parts. Correlation was also found by KAJANUS between blue flowers and orange brown seed color.

Spots on the Leaf. White spots on the leaf are caused by the destruction of chlorophyll grains and aerial cavity originated in the tissue. KAJANUS (250) observed that the basal spotted plants showed segregation after the monogenic scheme, 3 spotted to 1 spotless. Central markings gave a digenic segregation, 12 with central, 3 with basal and 1 without markings. Two genes were assumed, C for central, and B for basal. C is epistatic to B.

MAYER-GMELIN (457) and MALTE (814) also made similar observations.

Number of the Leaflet. According to DE VRIES (8, 13, 56) and KAJANUS (248), forms with many leaflets, e.g. five or four, are dominant to the normal three-leaved type, probably a single gene being involved.

Triticum

COLOR INHERITANCE

Grain. Wheat grains may be either red (brown) or white (yellow). Color in the red grain is due to a brownish or reddish pigment present in the testa of the seed which is absent in the white grain. A few Abyssinian varieties have purple- or violet-colored grains. This color is due to an anthocyanin pigment in the pericarp.

NILSSON-EHLE (119, 187, 188) made a cross between Svalöf 'Pudel' (white) and Swedish 'Sammet' (dark red). The F_1 grains were pale red. In F_2 the grains were also red, but of several shades. Some of the F_2 plants, however, showed segregation in F_3 in a ratio of 3 red : 1 white, others in a ratio of 15 red : 1 white, while still others in a ratio of 63 red : 1 white. For interpretation, he assumed three genes R_1 , R_2 and R_3 for red color. They are separately inherited and have a cumulative effect, the depth of color being proportional to the number of doses of the R gene present in the zygote.¹⁾ NILSSON-EHLE found further that the grain color of Svalöf 'Grenadier' wheat is a trimerous red, that of Extra Squarehead II, Bore wheat and Swedish *compactum* are a dimerous red.

The cross, red $\times$ red, was also made by him (361), in which the parents were Bore wheat and Extra Squarehead. In F_2 a ratio of 15 reds to 1 white was obtained, confirming the previous hypothesis.

The mono-, di- or trigenic ratios of reds to whites were repeatedly obtained by a number of investigators: BIFFEN (48), HOWARD & HOWARD (243), MALINOWSKI (359), MAYER-GMELIN (505), GAINES (1331), KAJANUS (554, 1033), LOVE & CRAIG (646, 1191), HARRINGTON (909), HARRINGTON & AAMODT (1018), CLARK (1117), HAYES & ROBERTSON (1149), LATHOUWERS (1183), MEYER (1289) and VAVILOV & JAKUSHKINA (1319).

The inheritance of purple color was studied by CAPORN (532). In the cross, white (*polonicum*) $\times$ purple (Eloboni = *durum*), purple color

1) The gene R for red color affects also the structure of the testa and power of germination of grains. (NILSSON-EHLE, 361).

is dominant in F_1 , and showed segregation into flushed (or full-colored), streaks and non-colored in a ratio of 3 : 1 : 12. Of 123 non-colored F_2 plants, 111 threw non-colored in F_3 and 12 threw non-colored and streaked. He believes that these two kinds of colorless were to each other as 15 : 1. The F_3 , however, did not give segregations analogous to the F_2 , being 12 flushed : 1 non-colored : 3 streaked. Further study is required for the elucidation of these complicated results.

Glume. The glume of wheat may be described as either black, brown or yellow, the black including various shades from black to gray, the brown various shades of brown and red, and the yellow also shades to almost white. Most investigators dealt with the cross, brown $\times$ yellow:—BIFFEN (48), MAIL (257), HOWARD & HOWARD (243), STRAUS (371), HENKEMEYER (404), MAYER-GMELIN (505), KEZER & BOYACK (557), HARRINGTON (909), KAJANUS (1033), AUSBORN (1106), CLARK (1117), LATHOUWERS (1183) and MEYER (1289). In general the difference between brown and yellow is monogenic, the brown color being dominant.

In his classical experiments on the cross, yellow (white) wheats and some brown (red)-chaffed Swedish 'Landwheat', both belonging to *vulgare*, NILSSON-EHLE (119, 187) obtained in F_2 a ratio of 3 brown : 1 yellow or in other cases 15 brown : 1 yellow. From these results, two genes were assumed R_1 and R_2 , each of which by itself produces a brown color and when acting together have a cumulative effect. They are, however, not of the same intensity, R_1 producing darker brown than R_2 .

The dimerous brown was also reported by MALINOWSKI (359) in the cross, brown *Spelta* $\times$ brown *vulgare*. In F_2 the ratio of 15 brown to 1 yellow was obtained. Later LOVE & CRAIG (646) likewise confirmed the hypothesis of NILSSON-EHLE. They made a cross of brown *vulgare* with yellow *durum*, and obtained F_1 plants with intermediate brown glumes, showing segregation in F_2 the ratio of 15 brown : 1 yellow. A similar result was also reported by MEYER (1289) in the brown *vulgare*-white *compactum* cross.

A very complicated result was obtained by KIESSLING (353). He observed in numerous cases an apparently irregular mode of inheritance of the brown color which did not accord with the ordinary Mendelian rule. The white plants often gave some brown plants in a complicated ratio. LINDHARD (934) also reports the occurrence of inverse ratio in the segregation in connection with the brown color in *vulgare*.

The cross, black $\times$ yellow, was tried by BIFFEN (48) and ENGLEADOW (341), who crossed a black (gray) *turgidum* with a yellow *vulgare*. The

F₁ plants were black-glumed and the segregation of 3 black or nearly black to 1 yellow occurred in F₂. PERCIVAL (1334) dealt with Black Emmer (*dicoccum*) and a yellow-chaffed *sphaerococcum*. In F₂ several types with the following chaff colors were found: uniform black, brown, yellow and chaff of these tints with black outer margins. Black proved, thus, to be dominant to brown. A similar result was obtained by KEZER & BOYACK (557) and also by KAJANUS (1033) in the hybrid, Black Emmer × white *vulgare*.

VAVILOV & JAKUSHKINA (1319) made a series of crosses between a black *persicum* (Persian wheat) and other yellow and brown races, and showed that black is monogenically different from brown or red. In the F₂ from black *persicum* × red *dicoccum*, they obtained black, brown and yellow in a dihybrid ratio of 12:3:1. Thus the gene for the black pigment proved to be epistatic to the gene for red, its absence resulting in white.

In crosses with Polish wheat, the inheritance of glume color seems to occur according to a more complex scheme. BIFFEN (430) in crosses of Polish wheat (white) with a gray-chaffed *turgidum* found the white color dominant to the gray. VAVILOV & JAKUSHKINA (1319) observed also the dominance of white *polonicum* over black *persicum*.

Auricle. KAJANUS (554, 555, 1033). Red auricles (Mazuolo Americano) are dominant to pale reddish (Pearl), segregation in F₂ occurring on a monogenic basis.

Awn. HOWARD & HOWARD (410). Crosses of black-awned Indian wheats with colorless (yellow) strains gave black-awned plants in F₁, and in F₂ a ratio of 3.45 black to 1 colorless.

SPIKE CHARACTERS

Spike Density. The inheritance of the lax ears and the mid-dense 'Squarehead' forms of *vulgare* and the short compact ears of *compactum* have been extensively investigated by a number of workers: BIFFEN (48), WILSON (85), NILSSON-EHLE (96, 119, 187), MALL (257), PARKER (363), GAINES (1331), KAJANUS (554, 1032, 1033), BOSHNAKIAN (880), ARCISZEWSKI (1105), NILSSON-LEISSNER (1291), MEYER (1289) and others.

In general the F₁ plants of the cross, *vulgare* × *compactum*, show a more or less clear dominance of the *compactum* type or a state intermediate in length and density of ears between the parents; in F₂ a monohybrid segregation—3 *compactum*: 1 *vulgare*, or 1 *compactum*: 2 intermediate: 1 *vulgare*—is observed. In some cases, however, every

gradation is found in F_2 between the parents, and in addition, some examples with both longer and shorter ears than those.

NILSSON-EHLE, in the cross of Swedish Binkel (*compactum*) with Pudel and Bore (*vulgare*), found that the lax character of *vulgare* is often dependent upon two independent genes, L_1 and L_2 , each of which by itself increases the length of the internodes of the ear, and which when acting together have a cumulative effect, and the compact character of *compactum* is dependent upon a single gene C which shortens the rachis internodes, and is to some extent—not absolutely—epistatic to L_1 and L_2 . According to this scheme, CL_1L_2 is very dense *compactum*, CL_1L_2 *compactum*, cL_1L_2 very long lax *vulgare* and cl_1l_2 'Squarehead'.

Later, ARCISZEWSKI, from the cross of Solmann's Squarehead (*vulgare*) $\times$ Blé carré de Sicile (*compactum*), found still another lengthening gene L_3 and also another gene M which inhibits the effect of the L genes, its effect being similar to that of the C gene of NILSSON-EHLE, but much weaker and restricted to the upper part of the ear.

The *subcompactum* type, so-called by KAJANUS, is a *compactum*-like form which often segregates out from several crosses with non-compact wheats, and behaves as a recessive to the lax ear of *vulgare*, in contrast with the true compactness dominating the laxness. It was obtained by MALINOWSKI (359) in F_2 of spelt $\times$ Squarehead, and likewise by MAYER-GMELIN (505) in several crosses, such as spelt $\times$ 'Gelder I' (with lax ears), spelt $\times$ Squarehead and spelt $\times$ Essex (with dense ears). KAJANUS also obtained similar results, and gave the following genic scheme: CL = *compactum*, cL = *vulgare*, and cl = *subcompactum*.

ENGLEDOW & HUTCHINSON (1250) made a cross, *durum* $\times$ *turgidum*, the former having laxer ears and a smaller average number of grains than the latter. The difference between the parents was found to be monogenic, the heterozygotes being intermediate. Ear density and average number of grains were genetically inseparable.

Spelting. In the *Spelta* wheat, the glume is stiff and thick with a very blunt apex, and is strongly keeled along the entire length and firmly attached to the rachis. Further in the *Spelta* the rachis-internode is somewhat longer than that of *vulgare*, the rachis is brittle, and the grains adhere firmly. These characteristics are always linked as if they were dependent on a single gene.

Spelta $\times$ *vulgare*. MALL (257), MALINOWSKI (359), LEIGHTY & BOSHNAKIAN (808), BOSHNAKIAN (987), KAJANUS (554, 1032, 1033), LATHOUWERS (1183), NILSSON-LEISSNER (1291) MEYER (1289).—In general the F_1 plants are intermediate in habit and show monogenic segrega-

tion in F_2 . On the other hand, LEIGHTY & BOSHNAKIAN report that in some cases the *Spelta-vulgare* cross gave in F_2 the ratio of 15 *Spelta* : 1 *vulgare*. They assumed two genes for the *Spelta* type, S_1 and S_2 , the *Spelta* wheat having genic composition of S_1S_2 , S_1s_2 or s_1S_2 , the *vulgare* wheat that of s_1s_2 . It was also found that there are modifiers which tend to dilute or intensify the spelt character.

LATHOUWERS obtained in F_2 a dihybrid ratio of 3 *Spelta* : 9 speltoids : 4 *vulgare*, in which the speltoid forms may be regarded as *Spelta*-forms with somewhat slighthened spelt-characteristics. For interpretation, a gene **D** was assumed, which inhibits the effect of the gene **S** for *Spelta*-type. Thus : **SD** = speltoid, **Sd** = *Spelta*, **sD** or **sd** = *vulgare*.

NILSSON-LEISSNER(1291) found that the genes lengthening the rachis-internodes act simultaneously as spelt-intensifying modifiers. It was concluded that the speltoids as well as certain diluted spelt types originated from the cross *Spelta* $\times$ *vulgare* are due to the absence of a number of these spelt-intensifying genes, which however are present in the pure *Spelta*. A similar interpretation was proposed by MEYER (1289).

Compactum $\times$ *Spelta*. BOSHNAKIAN (987), from the cross between *Spelta* (White *Spelta*) and *compactum* (Dale Gloria) obtained in F_2 a ratio of 9 dense *Spelta* (**CS**) : 3 lax *Spelta* (**cS**) : 3 dense non-*Spelta* (**Cs**) : 1 lax non-*Spelta* (**cs**). In this case the **CC** or **Cc** plants which lack **S** were found to be decidedly more dense than those carrying **S**, and moreover **C** remaining constant, plants carrying a single dose of **S** are more dense than plants which carry a double dose of **S**. Consequently the spelt gene **S** was considered to interfere decidedly with the full expression of the density gene **C**. The results obtained by KAJANUS (1032, 1033)¹⁾ were well in accord with those of BOSHNAKIAN. The **SC** type was called *compacto-Spelta* by KAJANUS. As already stated, NILSSON-LEISSNER, however ascribed these interrelations of genes to the pleiotropic effect of the lengthening genes.

Speltoid mutations. That a few speltoid (spelt-like) plants often occur among the offspring of pedigree cultures and also hybrids of *vulgare*, has been reported by several authors. The inheritance of these mutant forms has been investigated in detail by NILSSON-EHLE (507,

1) According to KAJANUS, the *Spelta* segregates from the *vulgare-Spelta* cross have the internode averaging over 2 mm. longer and about 2 spikelets less than the *vulgare* of the same generation. Their relation in F_2 was shown as follows :

	SS	Ss	ss
Rachis-internode length (mm.) :	5.82	5.27	3.68
Number of spikelets :	19.78	21.39	22.04

728, 824), VESTERGAARD (665, 852), KAJANUS (554, 1031, 1033), ÅKERMAN (671, 979) and LINDHARD (934, 1050). In most cases, these speltoids have been found to be heterozygotes, and are characterized by short and truncate glumes as in the true *Spelta*; the straws are longer and the ears more lax than the *vulgare* wheat. In a few cases heterozygous speltoids show segregation into normal (*vulgare*) forms, heterozygous speltoids and homozygous speltoids, in a ratio of 1:2:1. Homozygous speltoids are characterized by shorter stature and weaker growth than the heterozygotes. From this it is clear that the difference between *vulgare* and *speltoides* is monogenic, thus according to the scheme of KAJANUS, **VV** being *vulgare*, **Vv** and **vv** heterozygous and homozygous speltoids respectively.

In most cases, however, the proportion of the speltoids occurring in F_2 is smaller than that expected from the typical segregation. These cases are divided into two categories as to the mode of segregation. In one of these, the F_2 ratio of **VV**: **Vv**: **vv** is found to be (from 25 to 50%): (50%): (from 25 to 0%) in the extreme case, thus the ratio of these forms being 1:1:0, that is, homozygous speltoids being completely excluded. In the other mode of segregation, the number of heterozygotes is larger than that of *vulgare*, and speltoid homozygotes are not produced. These aberrant modes of segregation are explained on the assumption of the partial or total elimination of **v** ♂ gametes and of various degrees of reduplication of **V** ♂ gametes (NILSSON-EHLE, ÅKERMAN) or **v** ♀ gametes (LINDHARD).

Besides these, still another mode of segregation is known, in which the heterozygotes are fewer than in *vulgare* and no speltoid-homozygotes are produced. Probably reduplication of **V** ♀ and **V** ♂ gametes and elimination of **vv** zygotes will explain this mode of segregation (KAJANUS).

Hoariness of the Glume. The fact that the difference between pubescent and glabrous glumes is monogenic, the pubescent glume being dominant, has been repeatedly reported by several workers: BIFFEN (48, 430) in pubescent *turgidum* × glabrous *vulgare* and also in *vulgare* × *vulgare*, STOLL (147) in glabrous *Spelta* × pubescent *dicoccum*, HOWARD & HOWARD (243, 410) in *vulgare* × *vulgare* and also in pubescent *vulgare* × glabrous *compactum*, MALINOWSKI (359) in pubescent *dicoccum* × glabrous *vulgare* (?), STRAUS (371) and HENKEMYER (404) in *vulgare* × *vulgare*, MAYER-GMELIN (505) in glabrous *Spelta* × pubescent *vulgare*, KEZER & BOYACK (557) in *vulgare* × *vulgaie*, KAJANUS (181, 554, 1033) in *vulgare* × *vulgare* and also in glabrous *vulgare* × pubescent *turgidum*,

MEYER (1289) in *vulgare* × *vulgare* and pubescent *compactum* × glabrous *vulgare* and NILSSON-LEISSNER (1291) in pubescent *Spelta* × glabrous *vulgare*.

According to MALINOWSKI (359), the cross of pubescent *dicoccum* × glabrous *vulgare* (?) gave F₁ plants with hairs shorter than those of the *dicoccum* parent. The length of the hair of the *dicoccum* parent was 0.6–0.9 mm.; that of the heterozygote 0.3–0.4 mm. The F₂ segregation appeared to be monogenic, viz. 1 long-haired: 2 short-haired: 1 glabrous, indicating the extracted *dicoccum* parent, F₁ heterozygotes and the extracted *vulgare* parent respectively.

The HOWARDS (243, 410), in several crosses of pubescent *durum* × glabrous *vulgare* and pubescent *vulgare* × glabrous *vulgare*, obtained an intermediate condition in F₁ and a ratio of 15 pubescent: 1 glabrous in F₂. On examination under the microscope it was observed that the hairs on the glume of the felted parent were of two kinds, long silky and short hairs. F₁ plants were found to have a mixture of both types of hairs on the glume. It was concluded, through the F₃ test, that the velvet chaff is separately produced by two genes L and S, the former producing long silky hairs, and the latter giving short hairs. Plants containing both genes have a mixture of both hair types.

NILSSON-EHLE (728) found in a certain *vulgare*-line some half-pubescent plants in which the pubescence is confined to the upper extremity of the glume, and is composed of fine, short and thin hairs, so that the ears appear glabrous at first sight. Crossing experiments showed that full-pubescence, half-pubescence and glabrousness constitute a series of multiple allelomorphs, full-pubescence being monogenically dominant to the others, and half-pubescence being also simply dominant to glabrousness.

PERCIVAL (1334) obtained in F₂ of the hybrid between two pubescent-chaffed wheats, *dicoccum* × *sphaerococcum*, a ratio of 3 pubescent: 1 glabrous. According to him, RUMKER had observed a similar ratio of forms with glabrous and pubescent glumes in F₂ of the cross, pubescent *vulgare* × pubescent *compactum*.

ENGIEDOW & HUTCHINSON (1250) made a cross between *durum* and *turgidum*. In *turgidum* the hairs are long and evenly distributed, but in the *durum* parents they are shorter and more abundant on the keel and outer nerve than elsewhere. In F₂ a monogenic ratio of the *turgidum* type of pubescence to the remainder types was obtained.

Size of the Glume. BIFFEN (48) made reciprocal Polish (*polonicum*) × Rivet (*turgidum*) crosses. The average glume length of the Polish

parent was 28 mm.; that of the *turgidum* parent 9 mm. The F_1 was intermediate, with glume-length 17 mm. In F_2 the frequency curve was sharply divided into three sections in a ratio of 1:2:1. Similar results were found by CAPORN (532) in the Polish $\times$ Eloboni (*durum*) and also by BACKHOUSE (521) in crosses Polish $\times$ Rivet and Polish $\times$ Kubanka (*durum*). BACKHOUSE, however, could not separate the constituents of the glume-length distribution in F_2 . And so he determined the ratio of long-glumed and intermediate-glumed plants: short-glumed plants as 3:1.

A detailed study on the cross Polish $\times$ Kubanka was made by ENGLEADOW (691, 1003). For the parents the average glume-lengths were about 31 mm. and 12 mm. respectively. The F_1 plants were intermediate, the mean value of glume-length being 11–18 mm. In F_2 he obtained a trimodal distribution curve, the respective modes being 11.5 mm., 16.5 mm. and 25.5 mm., and its frequencies suggesting simple segregation on the 1:2:1 basis. The offspring of the long plants (extracted Polish) as well as the short ones (extracted Kubanka) remained constant, while that of the intermediate group repeated the F_2 segregation. The mean glume-length for the F_2 extracted Polish type, however, 'shifted' down by 24.83 % and this shifted value was found to breed true in F_3 . For the extracted Kubanka, a corresponding small upward shift seemed to have occurred. The nature of this 'shift' has not been clearly elucidated.

Firmly Closed and Loose Glumes. In *Spelta* the glumes firmly enclose the grains. According to KAJANUS (181, 301, 554, 1032, 1033) the close-fitting glumes of *Spelta* are dominant to the loose glumes of other wheats except in hybrids with *turgidum*, in which the close-fitting character is recessive; in both cases the segregation proved to be monogenic.

As regards the shattering of the ear, the HOWARDS (243) made a cross between a *compactum* (American Club) and a *vulgare* (Pusa b), and obtained in F_2 shattering and non-shattering plants in a 15:1 ratio. Two genes appeared to be involved in the shattering of the ear.

Awning. That the cross between bearded and beardless wheats gives in F_1 awnless or short-tipped plants, and in F_2 the segregation occurs in a ratio of 3 awnless: 1 awned or 1 awnless: 2 intermediate: 1 awned, has been generally accepted by a number of investigators—BIFFEN (48), WILSON (85), KAJANUS (181, 301, 554, 555, 1033), MALINOWSKI (359), STRAUS (371), HENKEMEYER (404), GAINES (1331), MEUNISSIER (567), KEZER & BOYACK (557), LOVE & CRAIG (646), HAYES & AAMODT

(1021), MEYER (1289), NILSSON-LEISSNER (1291), VAVILOV & JAKUSHKINA (1319) and others.

SAUNDERS (80) on the other hand questioned the monogenic difference between beardless and bearded forms, and showed that the length of awns of the F_1 generation varies with the wheats employed in the cross. In F_2 he obtained a continuous series of intermediates with two extreme types, fully bearded and completely beardless.

NILSSON-EHLE (728) obtained by mutation true-breeding forms of half-bearded and full-bearded among the offspring of beardless (short-tipped) races. Cross-experiments showed that beardless forms are partly dominant to full-bearded and half-bearded, and half-bearded forms to full-bearded, in each case the F_2 segregation occurs in the monohybrid ratio. The results were explained on the basis of multiple allelomorphs.

A detailed study of this subject was made by the HOWARDS (243, 410). They emphasized that most investigators have not worked with suitable materials; in the majority of the records, plants described as being awnless really had short tip awns. The cross they made between fully bearded and absolutely beardless *vulgare* gave in F_1 plants having ears with very short tips to the apical spikelets. In F_2 they obtained plants with quite beardless ears and a series of forms with awns of various length, the ratio of these two groups being 15:1. In the awned group, four classes were recognized: (1) Fully bearded, (2) nearly fully bearded, (3) long tips and (4) short tips. The short tipped plants crossed with the long-tipped ones gave in F_2 some fully bearded and some awnless plants as well as the intermediate forms. These results were explained by supposing two genes **B** and **T**, each of which alone causes long tips and short tips respectively, and which when combined have a cumulative effect. Similar results were obtained by HARRINGTON (909) in crosses with full-bearded, tipped and beardless wheats.

CLARK (1117), on the other hand, in the cross between Kota and Hard Federation, arrived at the conclusion that two genes at least must be present in a dominant condition in awnless strains, and the awned plants should be represented by at least double recessive genes. This is a hypothesis contrary to that of the HOWARDS.

Awning on the Empty Glumes. The awns of wheat when present are ordinarily grown on the flowering, and not on the empty glumes. A few wheats, however, are known to be characterized by an awn-like projection on the empty glumes. According to the observations of VAVILOV & JAKUSHKINA (1319), the feature is a characteristic of *persicum*, and

among *vulgare* wheats it is met with chiefly in forms from Turkestan, Persia and Bokhara.

As regards the inheritance of its length, FLEISCHMANN (439), in crosses of short $\times$ long, obtained an intermediate condition in F_1 and a almost continuous series of forms within the parental limits in F_2 , but showing a marked dominance of short lengths.

LOVE & CRAIG (646) observed the appearance of some plants with the awn on the empty glume in F_2 of a cross between a *vulgare* (Early Red Chief) and a *durum* (Marouani).

VAVILOV & JAKUSHKINA (1319) dealt with *persicum* which has long awn projections of 20 mm. or more in the middle part of the ear. In crosses of *persicum* with forms whose empty glumes are characterized by a short tooth, 0.5–2 mm. in length, the F_1 plants usually showed an intermediate state as regards this character. In a few cases (*persicum* $\times$ *vulgare*, *persicum* $\times$ *Spelta*), however, the short apical tooth was apparently dominant in F_1 . The decidedly complex genetical nature of this character was revealed in F_2 , F_3 and F_4 . Apparently it is conditioned by several genes.

Structure of the Rachis. In the two wild wheats, *T. aegiloides* and *T. dicoccoides*, the rachis of the ripe ear is very fragile. LOVE & CRAIG (646) found fragility of rachis as dominant to toughness in *durum* $\times$ *dicoccoides* and also in *dicoccoides* $\times$ *vulgare*. In F_2 the ratio of 3 fragile: 1 tough was obtained in both cases. They recorded further in F_2 of the cross, *vulgare* $\times$ *durum*, the occurrence of a few plants with fragile rachis similar to those of *dicoccoides*. The proportion in which they appeared 2 fragile: 111 tough, suggesting 1: 63 ratio of a Mendelian trihybrid.

VAVILOV & JAKUSHKINA (1319) observed that *T. persicum* also has a thin and fragile rachis. In crosses between this wheat and other common wheats with broad, tough rachis, the F_1 plants showed an intermediate condition of structure with a marked dominance of the Persian type. In F_2 the segregation of the broad type was found to take place only in a very small number. Among a hundred plants of F_2 from a cross of *persicum* $\times$ *durum*, only a single plant approached *durum*; the others were difficult to distinguish from the Persian type. These results suggest the existence of several genes concerned in this character.

Anomalies of the Ear. According to MEUNISSIER (567) and TSCHERMAK (1006), the normal (simple) condition is dominant to the branched ear of *turgidum*, and in F_2 the monohybrid segregation of 3 simple: 1 branched occurs. NILSSON-LEISSNER (1291) found some plants with

branched ears among the *Spelta*-individuals from the cross *Spelta* × *vulgare*. The branched condition was considered to be recessive, but dependent on several multiple genes. Similar occurrences of branched ears among the offspring of the cross with normal types were recorded by BIFFEN (430) in *polonicum* × *vulgare* and also by KEZER & BOYACK (557) in *vulgare* × *dicoccum*.

'Additional' spikelet or an occasional adventitious spikelet arising from underneath a normal spikelet, was found to be inherited by KAJANUS (1164) and NILSSON-LEISSNER (1291). The character proved recessive to the normal type, and was probably due to several multiple genes.

GRAIN CHARACTERS

Size of the Grain. BIFFEN (48) made the cross between Polish and Rivet, the average grain-length of the former being 10.1 mm., and that of the latter 7.2 mm. The F_1 grains averaged about 9 mm. long, and in F_2 long, intermediate and short grains appeared in a ratio of 1:2:1. Similar observations were made on the Polish-Kubanka cross by ENGLEADOW (691, 1003). The mean length of the grain of the Polish parent used was about 10.2 mm.; that of the Kubanka parent 7.7 mm. In F_2 three types were found with the following mean grain-lengths: 8.84, 8.67 and 8.33 mm., in a ratio of 1:2:1. No grains as long as those of the Polish parent and none as short as those of the Kubanka parent were obtained in this generation. In these cases, both BIFFEN and ENGLEADOW found that long glumes are invariably accompanied by long grains, and short glumes by short grains.

Later ENGLEADOW & HUTCHINSON (1250), in a *turgidum-durum* cross, showed that grain and glume length have different genes, and that there are at least two genes for grain length. The extreme of length and weight of F_2 grains exceeded the parental ranges in both directions. From these results it was concluded that *turgidum* must be genetically very different from *polonicum* and *durum*, although all three have 14 chromosomes.

According to VAVILOV & JAKUSHKINA (1319), the small grain of the Persian wheat is recessive to the large grain of *durum* and Polish wheats. The weight of 1,000 grains of the Persian wheat was 21.0 gr., that of a *durum* wheat was 36.0 gr. The average weight of separate progenies of F_4 hybrids fluctuated from 25 to 40 gr. Progenies of a medium weight were predominant.

HAYES (1019), in crosses between varieties of *vulgare*, pointed out a

relation of awned condition to length of grain. Preston produces longer seed than Marquis; the former is a bearded variety, while the latter is awnless (strictly speaking, short-tip-awned). Crosses between these two varieties showed that the bearded plants in heterozygous F_3 and F_4 progenies produced grains which on the average were about one millimeter longer than the grains produced by awnless plants.

Internal Structure of the Grain. The endosperm character, whether soft or hard, is greatly influenced by the environment. In most cases, soft wheats are easily changed to hard and *vice versa*. A few wheats, however, retain their characteristics under all conditions. BIFFEN (48, 89, 430), in the cross of Rough Chaff (soft) $\times$ Fife (hard), found that hard and translucent endosperm behaves as a simple dominant to soft and opaque endosperm. In another cross, Lemmas (soft) $\times$ Fife (hard), however, the dominance of the hard endosperm was not so sharply marked, and the heterozygotes could be easily distinguished from the homozygotes. According to him, hard strong wheats contain a higher total nitrogen percentage than soft weak wheats when grown under the same conditions. In this connection, he made a cross, Rivet $\times$ Polish, the former having a high nitrogen content (22 %) and hard grains, and the latter being low in nitrogen content (1.8 %) and soft. In the F_1 grain, the nitrogen content was 'probably high' (not studied). The F_2 generation showed a continuous series of forms, but with a bimodal frequency curve of nitrogen content, the modes being at 18 % and 21 %. Total number of plants with a low nitrogen content and soft grains was 26, and 63 appeared to be heterozygotes, and 21 were high in nitrogen content and had hard grains.

The HOWARDS (243) observed also a monogenic ratio from a cross of a constant soft White wheat with a strong translucent amber wheat, the heterozygotes being intermediate in structure of grains. They inclined to the opinion that softness *versus* hardness and high *versus* low nitrogen content are governed by different genes.

PEKLO (458), in crosses of *vulgare* $\times$ *vulgare* and *vulgare* $\times$ *durum*, found the F_2 segregation to be in a ratio of 1:1. In some cases, however, an aberrant ratio of 4 hard: 1 soft was observed.

FREEMAN (488, 543) making observations on the cross of a hard-seeded *durum* with a soft-seeded *vulgare*, found an intermediate condition in the F_1 endosperm. In F_2 a series of types grading from hard to completely soft grains appeared. Homozygous hard- and soft-seeded plants were obtained in F_3 . He considered that hard and soft endosperms depend on relatively high and low proportion of gluten and

starch, and assumed two genes for this character. Thus the great variability observed in F_2 was explained on the assumption of a cumulative effect of these genes and of the double fertilization which causes the presence of from none to six doses of the genes in the endosperm cells.

VAVILOV & JAKUSHKINA (1319) briefly noted that the hardness of the grain of the Persian wheat is dominant in crosses with a soft *turgidum*, and in F_2 plants with hard and semi-hard grains and those with soft grains appeared in a 3 : 1 ratio.

ENGLEDOW & HUTCHINSON (1250) made a cross of *turgidum* (soft) $\times$ *durum* (hard), and obtained the F_1 plants showing the *durum* endosperm type to be completely dominant. In F_2 the following types of endosperm were recognized: (1) grains like *turgidum*, (2) grains like *turgidum*, but with a small vitreous 'patch' in the starchy matrix, (3) grains not homogeneous, some more starchy than vitreous, others more vitreous than starchy, (4) grains like *durum*, but with a small starchy 'patch' in the vitreous matrix, and (5) grains like *durum*. Of 144 F_3 progenies only nine progenies had grains of a single type: the *durum* type, the proportion suggesting 1/16. The results were explained, though unsatisfactorily, on a digenic basis, assuming the following constitutions, *turgidum* = **ab**, *durum* = **AB**. **A** and **B** were regarded as genes producing separately a *durum*-like endosperm and jointly a true *durum* one.

Form of the Grain. ENGLEDOW & HUTCHINSON (1250) made a cross between *turgidum* and *durum*. In *turgidum*, the grain has the back high but roundly arched, while that of *durum* is humped rather than arched. This difference proved to be monogenic, the humped grain being dominant.

VAVILOV & JAKUSHKINA (1319) showed that the slight rugosity of the grain, a characteristic of 'Persian wheat', is a dominant feature in crosses with *durum*, *turgidum* and *dicoccum*. The F_1 plants showed distinct traces of minute rugosity. In F_2 from crosses with a *durum*, out of 83 plants investigated, 34 were fairly rugose, 20 slightly rugose, 19 almost smooth and 10 perfectly smooth like *durum*.

OTHER MORPHOLOGICAL CHARACTERS

Type of Seedling. According to the observations of PERCIVAL (1334), there are two types of young shoots: erect and prostrate. In the former type, shoots spring up almost vertically, while in the latter, they lie on the surface of the soil. The difference proved to be monogenic, the heterozygotes being intermediate and giving in F_2 a 1 : 2 : 1 ratio.

Height of Plant. FREEMAN (542) published a paper on the inheritance of the total height of plants from the ground to the top of the tallest head in several crosses. Crosses between Algerian macaroni (tall) and Sonora (low) and those between Red bread (tall) and Sonora (low) gave the F_1 plants in the average taller than the tall parent. In some other crosses, however, the F_1 plants proved intermediate between the parents. The results of F_2 suggested the existence of several genes for height of plant.

CLARK (1117), in a Kota-Hard Federation cross, briefly noted that tallness appeared to be partially dominant, but due principally to heterosis and was easily affected by environmental conditions.

As to the inheritance of *dwarfishness*, several investigators have made observations. VILMORIN (319) obtained a dwarf race in two lines of *compactum* (Beseler's Brown Club Head and Sirno). This dwarf race was found unfixable, always throwing in their progenies tall plants which on selfing breed true and dwarf plants which on selfing give again tall and dwarf. The ratio of dwarf to tall was about 1:2.5. These results were explained on the assumption that the dwarf plants are heterozygous and that there is repulsion between gametes carrying 'dwarfishness.' Later ENGLEDOW & WADHAM (1251) working with the same material derived from VILMORIN's dwarf found that plant-height appears to have a regular association with density of spike, and when classified by this character three distinct genotypes were recognized: lax, dense and pigmy. Their ear density increases in the order named; and their plant-height in the reverse order. Lax plants proved homozygous. Dense plants showed segregation, and fluctuated markedly in height and general development. The pigmy plants were self-sterile, very fluctuant and produced ears only under special conditions. Studies on the survival rates and proportions of these types in dense-plant progenies showed that there is still no plausible explanation for the phenomena.

On the other hand, NEETHLING (571) reports dwarf plants which seem to be monogenically recessive to the normal plants. The author, by crossing two common wheats of normal height, obtained in F_2 8 dwarfs in a total of 31 plants. The proportion in which the dwarfs appeared was considered to be in a 1:3 ratio.

CUTLER (614) described also dwarf plants occurring in Marquis wheats. The plants of lowest stature, about 9 inches tall, were found to produce a high percentage of dwarfs, in some cases 100 per cent. Ex-

tracted normals bred true, while intermediate plants produced dwarfs, intermediates and normals in a 1 : 2 : 1 ratio.

WALDRON (1224) likewise records the occurrence of dwarfs in F_2 of Marquis-Kota crosses. One of the normal F_1 plants, from which the greatest amount of data was secured, gave in F_2 normals and dwarfs in a ratio of 5 : 1. Out of the normal F_2 plants, 78 F_3 progenies were raised. Of these 36 produced no dwarfs and the other 42 progenies showed several different ratios of segregation: normals : dwarfs = 1:0, 3:1, 13:3, 55:9, 15:1 and 63:1. One of the dwarf plants of this series of the F_2 generation produced progenies in F_4 , with ratios of normals to dwarfs as follows: 1:0, 0:1, 1:3, 7:9, 1:15 and 1:63. In addition to these, an aberrant ratio of $1:29 \pm$ appeared. From these results, he assumed three genes. A gene **N** is responsible for normal height and epistatic to other genes. **D** is a gene for dwarfishness, and makes itself evident only in the presence of an activating gene, **A**. Thus the dwarfishness is represented as **nAD**, the other combinations all resulting in normal plants.

Thickness of the Straw. As to this character, TSCHERMAK (1006), in crosses between markedly different types, obtained an intermediate F_1 condition and a series of forms in F_2 . Several genes are concerned in this character.

Pith. BIFFEN (48), in crosses of *vulgare* $\times$ *turgidum*, recognized a monogenic difference between solid and hollow straws, the hollow condition being dominant. KAJANUS (554, 1033) explained his results also on a monogenic basis, positive homozygotes being characterized by the hollow straw and negative homozygotes by the solid, while heterozygotes were intermediate.

VAVILOV & JAKUSHKINA (1319) on the other hand reached a different conclusion. Crosses of *persicum* (solid) with several soft wheat varieties characterized by hollow straw gave the F_1 plants with solid straws but less prominent than in *persicum*. In F_2 intermediate types in general prevailed. It was concluded, that hollow straw is a definitely recessive character.

ENGLEDOW (691, 1003) and ENGLEDOW & HUTCHINSON (1250) made a series of crosses with respect to this subject. The parents used, arranged in order of solidness, were: (1) Polish (*polonicum*), (2) Rivet (*turgidum*), (3) Kubanka (*durum*), (4) a *durum*-form, and (5) Chinese (*vulgare*). Monogenic differences were obtained in crosses, (1) $\times$ (2), (2) $\times$ (5), (1) $\times$ (3) and (2) $\times$ (4), the ratio of hollow : remainder being 1:3 in each case. These results are suggestive of multiple allelomor-

phism, but in the non-hollow group were several intermediate forms, indicating that 'solidness' is to a certain degree under the influence of other straw characters. It was safely concluded that a greater amount of pith is dominant to a lesser amount.

Hairy Node of Stem. Nearly all varieties of wheat have glabrous nodes, while there are some with pubescent (velvet) nodes. According to LOVE & CRAIG (1192), a common wheat with pubescent nodes behaves as a simple dominant to a glabrous variety.

On the other hand VAVILOV & JAKUSHKINA (1319), from the cross, *persicum* (pubescent) $\times$ *durum* (glabrous), reached the conclusion that pubescence of nodes is conditioned by more than one gene. The F_1 plants from this cross had pubescent nodes; in F_2 out of 94 plants, 57 had slightly pubescent nodes, 26 were pubescent like *persicum* and 11 were somewhat more strongly pubescent. In F_3 out of 57 plants, belonging to the slightly pubescent group, 8 bred true, while of 11 strongly pubescent plants 2 produced constant strongly pubescent progenies; the remaining 82 progenies showed segregation in the most various ratios. In some plants an increase of pubescence was prominent.

Hairiness of Leaves. BIFFEN (48) found that the pubescent leaves of *turgidum* are dominant in F_1 to the less hairy leaves of *vulgare*.

VAVILOV & JAKUSHKINA (1319), in the cross of hairy *persicum* $\times$ smooth *durum*, obtained in F_2 a very few plants with smooth foliage (the numbers obtained being 460 pubescent and 10 smooth plants).

Wax Efflorescence. According to TSCHERMAK (1006), MICZINSKY ('07) obtained results indicating that the wax formation on the leaf surface is dominant to the smooth, green leaf. BIFFEN (430) records the appearance of plants with green leaves among the offspring of the cross, *polonicum* $\times$ *vulgare*, both parents having wax-covered, glaucous leaves.

Form of the Leaf. BIFFEN (48) reports that the broad leaf of *turgidum* prevails in F_1 over the narrow leaf of *vulgare*, and the F_2 segregation occurs in the ratio of 1 broad : 2 intermediate : 1 narrow.

FREEMAN (542), in the cross of Algerian Red Bread (leaves medium in breadth) with Sonora with broad leaves, found all F_1 , F_2 and F_3 plants had a greater average leaf width than the more narrow-leaved parent. In the Red Bread-Early Baart cross (the parents having essentially equal leaf width), the average of the F_1 plants was a little below either parent. The average of the whole F_2 population was the same as that of the wider leaved parent. Genic analysis was not given.

PHYSIOLOGICAL CHARACTERS

Resistance to Rust. 1) Resistance to *Puccinia glumarum*. BIFFEN (48, 69, 220) found that on crossing immune forms of *T. turgidum* (Rivet), *T. compactum* (American Club) and *T. vulgare* (Hungarian Red) with very susceptible forms of *T. vulgare* (Michigan Bronze, Preston and Hungarian White), the resulting offspring is susceptible, and in F_2 the segregation occurs in the 3 : 1 ratio. Where the degree of susceptibility differs in the two parents the hybrid resembled the more susceptible parent, and in F_2 the two degrees of susceptibility appeared in the 1 : 3 ratio of slightly to very susceptible individuals.

Later NILSSON-EHLE (187) in hybrids between more or less susceptible and resistant forms of *T. vulgare* found that the F_1 plants resembled the susceptible parent in some cases, the resistant or intermediate in other cases. In F_2 segregation was evident, but the segregates were graded continuously between resistant and susceptible plants. Results were explained on the multiple gene basis.

ARMSTRONG (866) made a detailed study on the cross between a susceptible *vulgare* and a resistant *compactum*, and obtained F_1 plants showing susceptibility of an intermediate nature. In F_2 clear segregation was observed, indicating that the parents differed by a single main gene for susceptibility.

Recently, ENGLEADOW & HUTCHINSON (1250) published results from a cross of *turgidum* $\times$ *durum*, the former being slightly susceptible to *P. glumarum*, while the latter were much more susceptible. Here the difference proved dependent on several genes. Among the F_2 and F_3 plants were forms less susceptible than the *turgidum*, and others much more susceptible than the *durum*.

2) Resistance to *Puccinia graminis*. POLE-EVANS (194) showed that the susceptibility to black stem-rust was dominant in the cross between two *vulgare* varieties (Bobs $\times$ Wol Koren).

According to STAKEMAN, LEVINE & LEACH ('18, in Jour. Agr. Res., 16), there are a number of biological or racial forms of rust which are constant in their reactions to pure-line wheat varieties.

HAYES, PARKER & KURTZWELL (704) made observations on crosses of resistant emmers (*dicoccum*) and durumms with susceptible Marquis (*vulgare*). A single rust form was used in making the artificial epidemic. In the *vulgare-durum* crosses, the F_1 plants were as susceptible as the *vulgare* parent, and in some of the F_2 and F_3 generations transgressive segregation occurred, a few plants being more susceptible or more

resistant than either of the parents. In the *vulgare-dicoccum* hybrids, however, resistance was dominant, though not so resistant as the *dicoccum* parent. Segregation for resistance and morphological characters was studied in later generations. Some evidence of linkage of the *durum* and *dicoccum* characters and resistance to rust were found. In an examination of more than 20,000 F_3 plants, only a few showing *vulgare* spike characters and resistance were obtained.

WALDRON (856) worked with the hybrids between a resistant *durum* (Kubanka) and a susceptible *vulgare* (Power five-spring wheat). It was found that susceptibility is homo- or hetero-zygotes, resistance homozygotes and probably there exist two genes for susceptibility. Further he observed high linkage between the *durum*-type and resistance to rust.

PUTTICK (830) made crosses of a *vulgare* (Marquis) with a *durum* (Mindum), studying the inherited reaction to disease occasioned by two biologic forms of *Puccinia graminis* (Form I and Form XIX). It was found that the parental plants react reciprocally to the biologic forms used. The F_2 plants showed all gradations between complete susceptibility and immunity to both forms of rust. A single main gene, together with some modifying genes, was found to be responsible for the manner of reaction to Form XIX. But as for the manner of reaction to Form I, no such evidence was obtained.

Later, MELCHERS & PARKER (936) found a single gene to be responsible for the resistance in crosses of Kanred with Marquis, Preston and Haynes Bluestem, which were inoculated with a single form of rust. Segregation in F_2 was 3 resistant : 1 susceptible.

AAMODT (861, 978) crossed Kanred with Marquis. Kanred is resistant to a number of biologic forms of *Puccinia graminis*, whereas Marquis is susceptible to most of them. In greenhouse studies with the immune strains, immunity was found to be dominant. No intermediates were obtained. Here a single gene apparently determined the reaction to several biologic forms, to 11 of which Kanred is immune.

HARRINGTON & AAMODT (1018) made a study of the inheritance of resistance to two biologic forms, Form I and Form XXXIV, on the F_3 progeny from crosses between three varieties of *durum*: Mindum, Pentad and Kubanka No. 8. Form I attacked Pentad, but had no effect on Mindum, while Form XXXIV infected Mindum severely, but developed weakly on Pentad. Kubanka No. 8 was susceptible to Form XXXIV. The crosses Mindum $\times$ Pentad and Kubanka $\times$ Pentad gave in F_3 all combinations of susceptibility and resistance to these forms. The reaction of Kubanka-Pentad F_3 progenies to Form XXXIV indicated

the presence of two genes, neither susceptibility nor resistibility being dominant. The results obtained from Mindum-Pentad F_3 progenies inoculated with Form I, however, were explained on the basis of a single main gene difference, immunity being dominant. The data for the reaction of same cross F_3 progenies to Form XXXIV gave some evidence that a single gene was present, but dominance was not apparent.

HAYES & AAMODT (1921) studied the reaction of the cross, Marquis $\times$ Kota, to two biologic forms, Form XIX, to which Marquis was resistant and Kota moderately susceptible, and Form XXVII, from which Kota was immune and to which Marquis was resistant. With respect to Form XIX, F_3 progenies were obtained which reacted in a manner similar to the parents, while other progenies were obtained which were clearly heterozygous. The results could not be explained on the monogenic basis. As for Form XXVII, the F_3 plants consisted of the parental types, several heterozygotes and also homozygotes for susceptibility. Immunity appeared to be dominant to both resistance and susceptibility. The results were explained on the basis of two genes for immunity and resistance contained in the Kota and Marquis parents, respectively, each gene being allelomorphous and dominant to a gene for susceptibility.

Recently, CLARK (1917), in the cross between Kota (resistant) and Hard Federation (susceptible) found that resistance was recessive, and in F_2 the segregation occurred in a ratio close to 1:15. But in F_3 none of the resistant F_2 strains bred true, though evidence was shown that strains homozygous for resistance could be obtained in F_4 .

3) Resistance to *Puccinia triticina*. According to KAJANUS (1930), BACKHOUSE ('17) found on the cross between immune and susceptible *vulgare* varieties that the F_2 segregation was 3 susceptible: 1 immune.

4) Resistance to *Tilletia tritici*. GAINES (544, 695, 1009, 1256) made a detailed study on the inheritance of resistance to bunt in crosses with *vulgare*, *compactum* and *turgidum*. It was found that resistance to bunt is not a simple Mendelian character, but is due to the combined effect of a number of genes, for a continuous series ranging from complete immunity to complete susceptibility was obtained in F_2 .

5) Resistance to *Tilletia foetans*. THATCHER (1846), in the cross of *vulgare* $\times$ *Spelta*, investigated the reaction to *Tilletia foetans*. In F_2 three types were obtained: plants of which all the grains of all the spikes were infected; those of which all the grains of a part of the spikes were infected; and those of which all the grains of all the spikes were free

from infection. Their respective proportions were close to a 1:2:1 ratio. A single gene was assumed to be responsible for susceptibility.

6) Resistance to *Claviceps purpurea*. According to BIFFEN (220), crosses between two immune types of *vulgare* and *turgidum* gave a susceptible F_1 . It was assumed that two complementary genes are necessary to produce susceptibility to *Claviceps*.

7) Resistance to *Erysibe graminis*. VAVILOV (374) and VAVILOV & JARUSHKINA (1319), in crosses between immune Persian wheat (*persicum*) and susceptible *turgidum* wheats, showed that immunity was strictly dominant and that in F_2 resistant plants were prevailed numerically. In a cross where data are given (1319), 36 susceptible plants appeared in a total F_2 of 199 plants. It was concluded that the immunity of Persian wheat is due to several genes. In crosses of forms of medium resistance or showing relatively little immunity with strongly susceptible forms, however, susceptibility proved to be dominant to immunity.

8) Resistance to *Ustilago tritici*. According to OLSON *et al* (729), there are several genes involved for smut resistance in different wheat varieties, which are transmitted independently and have a cumulative effect when they act together.

Spring and Winter Types. According to TSCHERMAK (1006), winter habit behaves as a dominant character to spring habit. On the other hand, STOLL (147), VAVILOV & KOUZNETSOVA (1096) and AAMODT (861, 978) proclaimed that spring wheats dominate or prevail over winter wheats. VAVILOV & KOUZNETSOVA obtained in F_2 springs and winters in a ratio of 10:1, the actual numbers obtained being 234 homozygous springs, 266 heterozygous springs and 36 homozygous winters. In F_3 , the segregating strains gave a ratio of 4 springs: 1 winters. They found further that tiller number was strictly correlated with vegetative habit.

AAMODT obtained in F_2 a ratio of 5 spring: 1 winter in the Kanred (winter)-Marquis (spring) cross. He also reported the possibility of linkage between awns and vegetative habit in this cross.

According to KAJANUS (1340), NILSSON-EHLE ('15) from crosses between spring and winter wheats obtained F_1 plants with spring habit, and in F_2 the normal segregation of one winter to three springs. He recorded further the occurrence of a few winter wheats in F_2 of crosses between two spring types. The ratio of springs to winters seemed to approach 15:1, indicating that two duplicate genes are responsible for

the spring habit. Similar results were also obtained by NILSSON-LEISSNER (1291).

OLSON *et al* (729) found springs different from winters by a single gene, the F_2 of spring-winter crosses giving a 1:2:1 ratio of springs, plants ripening late, and winters. It was further reported that dwarfishness seemed to be associated with late ripening, and was thought to be probably linked in some degree to the winter habit.

COOPER (997) studied true winters (Dawson, Kanred and Fulcaster), true spring (Haynes Bluestem) and an intermediate type (Marquis) which matures one to two weeks later in the spring than the true winter type. Crosses of Marquis with three true winters produced approximately 13 springs to 3 winters in F_2 . He concluded that there are concerned two genes for the growing habit, **S** for winter habit and **I** inhibiting the effect of **S**. The genic constitution for the true winter type was assumed to be **SSii**, for Marquis **ssII**, and for the true spring type **SSII**. The results in F_3 , however, did not well accord with this hypothesis.

Early and Late Ripening Period. BIFFEN (48) made a cross of Polish, an early wheat, and Rivet, a late wheat. The F_1 plants were somewhat earlier than the Rivet parent, and in F_2 the segregation occurred in a ratio of 1 early : 2 intermediate : 1 late.

TSCHERMAK (1006) in the cross between two *vulgare* wheats observed that earliness prevailed in F_1 , and obtained a complex segregation in F_2 . Similar results were also reported by NILSSON-EHLE (191). It was assumed that several multiple genes were responsible for the ripening period.

FREEMAN (542) using parents with wide differences in heading dates (the cross being *durum* $\times$ *vulgare* and *vulgare* $\times$ *vulgare*) showed that the average dates of F_1 and F_2 were in every case intermediate and nearer to the late parent. In the *durum* cross, there was an extension of range much beyond that of the late parent. According to him, the heading date may be governed by three or more genes.

THOMPSON (591, 659, 847), dealing with eight varieties of *vulgare*, made a number of crosses between plants differing only slightly, likewise crosses involving greater differences with regard to length of ripening and heading periods. The F_1 plants matured with the late parent, F_2 giving a continuous segregation extending nearly from that of the earliest to that of the latest of the parental varieties.

According to PERCIVAL (1334), the ripening period is correlated with the type of young shoots, early wheats always having upright

shoots, while in the latest forms the young shoots are prostrate and hybrids are intermediate with semi-erect young shoots, showing segregation in F_2 in a 1:2:1 ratio.

BRYAN & PRESSLEY (763), in a Sonora-Turkey cross, found F_1 intermediate in time of heading between the parents and of F_2 the majority inclined toward the late parent.

FLORELL (1140) working at a Sunset-Marquis cross showed the dominance of earliness in F_1 , and that the F_2 segregation was 3.07:0.93, indicating 'one allelomorphic pair of factors, with possibly a number of minor modifying factors'. A similar monohybrid segregation was obtained by CLARK (1117) in a Kota-Kanred cross.

Winter-hardiness. According to NILSSON-EHLE (191) winter-hardiness in *vulgare* wheats is not a single unit character. Complex segregation was obtained in F_2 and plants homozygous for different degrees of winter-hardiness were produced in later generations. The results suggest that winter-hardiness is governed by several multiple genes.

Sterility. A study of the inheritance of sterility was made by MALINOWSKI (565, 721) in crosses between several varieties of *vulgare* and *dicoccum*. The degree of fertility was expressed by dividing the number of seeds by the number of spikelets in the head. It was found that partial and complete sterility is caused when two or more discordant genes meet in the same zygotes, and also that the degree of sterility depends on the number as well as the quality of these genes.

Standing Power. According to the HOWARDS (243), standing power is due to strong straw and power to form a strong root system. They made a cross between a *vulgare* with strong straw but inferior rooting power and another variety that had weak straw but good rooting. In F_2 all combinations of these characters appeared — well-rooted wheats with strong straw, well-rooted wheats with weak straw, wheats with strong straw and inferior rooting power, as well as some which had neither good straw nor good rooting power.

LINKAGE RELATIONS¹⁾

Glume-color and Glume-length. From crosses of a black type originated from a black *turgidum* × yellow *vulgare* cross with a yellow *turgidum*, BIFFEN (430) obtained in F_1 a blackish color and in F_2 a

1) The haploid chromosome number in the genus *Triticum* is as follows: 21 in *vulgare*, *compactum* and *Spelta*; 14 in *dicoccum*, *dicoccoides*, *durum*, *turgidum*, *polonicum* and *persicum*; 7 in *monococcum* and *aegilopoides*. (Vide TISCHLER, loc. cit.).

segregation into black and yellow, in which the black appeared only in the plants with short and intermediate glumes.

Another observation was made on a cross between a yellow *polonicum* and a black *turgidum* by BACKHOUSE (521). F_1 had yellow or faintly colored glumes. In F_2 there were yellow, tinged and deeply colored segregates, the deepest color being associated with the short glumes, namely, the gene for the long glume apparently inhibiting the color.

Glume-color and Pubescence. As regards the relation between pubescence and the color of the glume, KAJANUS (554, 1033) found that the pubescence of *Spelta* and *dicoccum* is always associated with the dark color, and is considered to be caused by a single gene **G**. In the hybrid, *Spelta* $\times$ *vulgare*, the effect of this gene becomes very slight, even in the homozygous condition, i.e., the pubescence is confined to the upper part of the glumes and the hairs are not so dense as in *Spelta*. The association of pubescence with brown color was observed further by KEZER & BOYACK (557) in *vulgare* $\times$ *dicoccum* and likewise by PERCIVAL (1334) in *dicoccum* $\times$ *sphaerococcum*.

BIFFEN (430), in the *turgidum-vulgare* cross, observed complete linkage between black color and the pubescence of the glume. A similar observation was made by VAVILOV & JAKUSHKINA (1319) in crosses of Persian wheat (*persicum*) with several other wheats (*durum*, *vulgare*, *compactum* and *Spelta*). ENGLEDOW (341) crossed a black-glumed wheat originating from a *turgidum*-life cross with a rough-chaffed, yellow-glumed variety, Essex Rough Chaff. The ratio obtained in F_2 was explainable on the basis of repulsion between the genes for black glume color and those for hairy chaff on the 1 : 3 : 3 : 1 series of gametes. Likewise HENKEMEYER (404) in reciprocal crosses between a pubescent yellow *vulgare* (Greek) and a glabrous brown *vulgare* (Red Prolific) obtained results showing partial repulsion between the gene for pubescence and that for brown color, while in crosses between Greek and two other glabrous brown *vulgare* varieties he met with no linkage phenomena.

Independent inheritance of pubescence and brown color was also reported by BIFFEN (48) in crosses between two *vulgare* varieties, pubescent yellow $\times$ glabrous brown. An analogous result was obtained by MAYER-GMELIN (505) in the cross between a *Spelta* with glabrous, brown ears and a *vulgare* with pubescent, yellow ears.

According to KAJANUS (554, 1033), the cross between two *vulgare* types, pubescent yellow $\times$ glabrous brown, gave results suggesting partial repulsion between the genes for pubescence, **H**, and that for

brown color, **B**, in the gametic series of 1:15:15:1. Similar linkage relations were found for **B** and **G** (the gene causing the black color associated with pubescence), and also for **H** and **G** in the cross between *Spelta* having **G** and *vulgare* having **H** or **B** respectively. In these cases the repulsion appeared to be absolute. But in a series, *vulgare* (**hbg**) $\times$ *turgidum* (**HBg**), the genes **B** and **H** were independently transmitted, giving in F_2 the segregation of 9 pubescent dark brown (**HB**), 3 pubescent yellow (**Hb**), 3 glabrous dark brown (**hB**) and 1 glabrous yellow (**hb**). Similar independent inheritance was observed for **B** and **G** in the cross, *vulgare* (**bg**) $\times$ *dicoccum* (**BG**).

Glume-length and Pubescence. BIFFEN (430) reports that the cross between a fully pubescent *turgidum* with short glumes and a faintly pubescent *polonicum* with long glumes gave in F_2 long- and short-glumed segregates and also pubescent and glabrous ears, in which the long-glumed plants had almost glabrous glumes, while the short and intermediate plants always bore pubescent ears.

BACKHOUSE (521) made a cross of *polonicum* with *durum*, the former having faintly pubescent glumes, while the latter (Kubanka) is a glabrous-chaffed wheat. F_1 was more pubescent than the *polonicum* parent. In F_2 he found that pubescence is related to glume length. Among the homozygous short-glumed plants 3 pubescent to 1 glabrous plant was obtained, and in the heterozygote the ratio of pubescent to smooth approached 3:1, while all the homozygous long-glumed plants had glabrous chaff. It was assumed that the gene for long glume inhibits pubescence. An analogous result was obtained by ENGLEDOW (691) in a similar *polonicum-durum* cross.

Awning and Other Characters. In crosses between awned *Spelta* and awnless *vulgare* or *compactum*, KAJANUS (1033) found that the gene for the awned condition (**n**) and that for the spelt characters (**S**) were coupled in inheritance, with a crossing over of about 35%. NILSSON-LEISSNER (1291) and MEYER (1289) observed a similar fact in the *Spelta-vulgare* cross. MEYER also records a partial coupling of brown glume color with the spelt characters.

Further, KAJANUS crossed an awned *speltoides* originating from *vulgare* $\times$ *turgidum* with an awnless *vulgare*. The results suggested a partial linkage between the gene for the awnless condition (**N**) and that for the *vulgare*-type (**V**), with a crossing over of about 33%. In some crosses, however, the results indicated almost absolute coupling between **N** and **V**, while in others these genes were inherited independently.

According to LOVE and CRAIG (1192), the characteristic pubescent

node is very closely (almost absolutely) linked with the awned condition.

Tropaeolum majus

Flower Color. RASMUSON (576) found a monogenic difference between dark yellow and light yellow, both being due to a plastid pigment, and likewise between red anthocyanin and its absence. The homozygotes are dark red and the heterozygotes light red. In a later publication (734), the author also showed that variegated flowers are dominant to self-colored.

Habit of Growth. RASMUSON (734) also described two varieties, one with a long creeping stem, and the other showing a dense *nana*-form. Crosses between these two types resulted in F_1 plants of the creeping type and monogenic segregation in F_2 .

Chlorophyll Deficiencies. In the same paper, RASMUSON showed that the dark green color of the leaf is determined by two genes. If either is absent, the color is probably green. Green was further found to be dominant to yellowish green, and both to variegated.

CORRENS (684) published a more extensive work on this subject. Chlorina is a pale green type and albopulverea is a type showing a white-green mosaic. Crosses between typica albopulverea (white-spotted green) and chlorina gave in F_1 the normal green type and in F_2 four distinct phenotypes: typica homogenea, typica albopulverea, chlorina homogenea and chlorina albopulverea in a 9:3:3:1 ratio. The results were explained by assuming three genes: **C** for chlorina, **N** producing typica in the presence of **C**, and **H** for solid leaf-color. The scheme of the genes may be represented as:

CNH.		typica homogenea,
CnH.		chlorina homogenea,
CNh.		typica albopulverea,
Cnh.		chlorina albopulverea.

Species-Crosses. WARREN (668) made a species-cross, *Tropaeolum majus* $\times$ *T. minus*. In the former, the corolla is pale yellow, leaves large uniform green and the stature tall; while in the latter, the corolla is red, leaves small and variegated, and the stature is dwarfish. From this cross the following three allelomorphs were recognized (the first given members being dominant):

- 1) Red—pale yellow corolla,
- 2) Normal green—variegated leaf,
- 3) Tall—dwarf stature.

In this case the genes for the chlorophyll character and the growth habit were found to be partially linked together, with about 21 per cent of crossing over. As to size of leaves, he obtained no clear segregation, but it was shown to be closely correlated with tallness and to a less extent with non-variegation.

FISCHER (284) working with *T. pinnatum*, the hybrid between *T. minus* and *T. peregrinum*, found that red anthocyanin in the corolla, petiole and stem proved dominant to its absence. The segregation suggested a monogenic scheme.

Urtica

Leaf Margin. CORRENS (38, 534) published papers on the species cross between *Urtica pilulifera* and *U. Dodartii*. The former has much serrated leaves, while in the latter they are nearly entire. The adult F_1 plants were indistinguishable from the *pilulifera* parent, as were also the cotyledonal stages of the seedlings, but the young hybrids differed from the latter by the character of the apices of the first three or four pairs of leaves which showed the clear dominance of the *Dodartii* parent. That is to say, in these earlier leaves, the *Dodartii* character is partially dominant, but in the later leaves the *pilulifera* character becomes completely dominant. As an explanation, CORRENS assumed two genes, **D** for *Dodartii* and **P** for *pilulifera*. In the hybrids, the gene **D** becomes active earlier in the development than the gene **P**, and after these stages **P** manifests itself, inhibiting the effect of **D**.

Chlorophyll Deficiencies. CORRENS (110) observed some yellowish green (chlorina) plants in F_2 of *U. pilulifera* $\times$ *U. Dodartii*. Crossing experiments indicated a monogenic difference between these chlorina and the normal plants, the latter being dominant. There was also some evidence suggesting that white seedlings are recessive to the chlorina type.

In later publications (534, 885), he studied a yellowish form (pereaurea) of *U. urens* which gradually becomes green in color and may mature. This type, when selfed, gave 2 peraeaurea to 1 green. Satisfactory evidence was obtained to show that the yellow homozygotes are non-viable, the surviving peraeaurea being always heterozygous.

Verbascum Blattaria

SHULL (101). The bright yellow color in the corolla is dominant to the pale yellow, almost white, and the F_2 segregation is monogenic.

Veronica gentianoides

Length of Style. CORRENS (1335). The character 'short-styledness' proved to be a heterozygous dominant (**Aa**), and the character 'long-styledness' a pure recessive (**aa**). In the typical 'short' and 'long' forms, the style averages 4 and 8 mm. long respectively. These lengths, however, are not always constant, but are modified by a set of minor polymerous genes (**L₁**, **L₂**, **L₃**, etc.).

Chlorophyll Deficiencies. CORRENS (684). The variety, *albocincta*, is a white-margined type of variegation. It is self-sterile. In crossing with normal green plants, nothing but green plants appeared in **F₁** and **F₂**, indicating no inheritance of this character.

Veronica longifolia

DE VRIES (8, 56). The presence of anthocyanin in the corolla behaves as a dominant to its absence. The **F₁** hybrid occasionally produced white flowers.¹⁾

Veronica syriaca

Flower Color. LEHMANN (356, 500) found a monogenic difference between blue and rose, and likewise between blue and white, in both cases the blue color being dominant.

Self-sterility. The same investigator (642, 931) studied the inheritance of self-sterility in this species. He found no single self-fertile plant in this species, and moreover certain combinations resulted repeatedly in cross-sterile. A cross between two plants was made, and 198 plants were raised in **F₁**. All proved perfectly self-sterile. From further crossing experiments, 131 of these plants were divided into four sterility-classes, A, B, C and D, each member of a given class being reciprocally sterile with every other member of that class, but reciprocally fertile

1) Of this variation DE VRIES (56, p. 285) says: "This reversion is not common, but in thousands of flowering spikes one may expect to find at least one of them. Sometimes it is a whole stem springing from the underground stem and bearing only white flowers on all its spikes. In other instances it is only a side branch which reverts and forms white flowers on a stem, the other spikes of which remain bluish. Sometimes a spike even differentiates longitudinally, bearing on one side blue and on the other white corollas, and the white stripe running over the spike may be seen to be long and large, or narrow and short in various degrees."

with members of any other class. The numbers of plants belonging to each class were: A, 35; B, 27; C, 37; D, 31, being thus nearly equal. Further, the author made several double combinations. When the progeny from crosses of the same sort were combined, such as $(B \times D) \times (B \times D)$, the members from each cross were divided into two classes, I and II, intra-sterile, but partly inter-fertile, each of which consisted of about an equal number of individuals. On the other hand, the combination of different sorts, such as $(B \times D) \times (A \times D)$, resulted in one of the four combinations in sterility, all the remainder being fertile, with one exceptional case, $(B \times C) \times (B \times D)$, in which every combination proved fertile. LEHMANN explained these results by assuming that there are four sterility genes $\alpha\beta\gamma\delta$ and two reciprocally sterile classes possess any one of them in common. Thus BD II and AD II were found to carry

TABLE XXXV.—INHERITANCE IN *Vicia Faba*.

Contrasted characters	F ₁	F ₂	Authors
<i>Seed Coat Color</i>			
Black—yellowish brown	Black		TSCHERMAK (in 896)
Brown—gray or green	Brown		BLARINGHEM (758)
BLARINGHEM observed in F ₂ of <i>V. F. equina</i> × <i>pliniana</i> a new character : marbling or spotting on the seed coat.			
HEUSER (1024) observed segregation in a spontaneous hybrid, in which black was dominant to 'normal', and violet to 'normal'.			
Reddish gray—violet	Intermediate (light violet with a grayish tinge)	1 : 2 : 1	} KAZNOWSKI (1169)
Reddish gray—green	Pale green	1 : 2 : 1	
Black eye—white	Black eye	3 : 1	SIRKS (742)
Black eye—pale gray	Deep gray or gray	1 : 2 : 1	KAZNOWSKI (1169)
<i>Size of Pods & Seeds</i>			
Large—small	Intermediate	Segregation (Multiple genes)	{ TSCHERMAK (in 896) KAZNOWSKI (1169)
<i>Chlorophyll Deficiencies</i>			
Pale yellow—green	Green	Segregation	} KIESSLING (352)
Yellowish white-variegated—green	Green	Segregation	
These deficiencies were shown in the first leaves only, the leaves developing later being normal. Moreover there were several grades of defects. From complex segregation found in F ₂ and F ₃ , KIESSLING assumed a number of genes for chlorophyll development.			

the gene α , AD I and BC II the gene β , BD I and AC I the gene γ , and probably BC I and AC II the gene δ .

Vicia Faba

A summary of inheritance in *Vicia Faba* is given in the above table (TABLE XXXV).

Vigna sinensis

Flower Color. HARLAND (626) treated with three varieties of flower color, deep reddish violet, pale violet and white. Results from crossing indicated the presence of two genes for flower color, **L** for pale flowers and **D** for dark flowers. These genes were found to have no visible effect except in presence of the gene **R** (red seed coat pattern). Thus **RDL** is dark, **RdL** pale, and the other combinations result in white.

In a later publication (698), HARLAND described an additional variety of flower color, 'tinged' which was obtained in F_2 of the cross, red $\times$ white (a variety 'Para'). This type was shown to be due to a gene **G**, dominant to its absence, but hypostatic to **D**.

Color of Seed Coat Pattern. Some earlier observations on the inheritance of seed coat color were made by SPILLMAN (314). He found that all forms with coffee-brown, white or cream-colored seeds have white flowers, and are without anthocyanin in stems and leaves.

More recently, HARLAND (626, 698), working with several varieties, obtained the following results:

- 1) Brown and red gave brown F_1 , showing segregation in F_2 into 12 (brown + buff) : 3 maroon : 1 red.
- 2) Black and brown gave black F_1 , showing segregation in F_2 into 3 black : 1 brown.
- 3) Red and white gave buff F_1 , and 9 buff : 3 red : 4 white in F_2 .
- 4) Black and white gave black F_1 , and 9 black : 3 buff : 4 white in F_2 .
- 5) Black and buff gave black F_1 , and 12 black : 3 buff : 1 red in F_2 .

The results were explained by assuming four genes, **B** (black), **N** (buff), **M** (maroon) and **R** (red). The relationship between these genes may be represented thus:

RB(NM) black,
RbNM brown,
RbNm buff,

RbnM maroon,
Rbnm red,
 Absence of **R** white.

When **B** is present in a heterozygous condition, the mottling occurs, but some plants showing slightly mottled seeds may be pure for this gene.

HARLAND (698) also described an additional variety, the New Era, in which the seeds are uniformly dotted with a dark blue anthocyanin pigment on a buff background. In crosses with white, this type behaved as a dominant, and gave in F_2 a ratio of 9 New Era : 3 buff : 4 white indicating that the New Era pattern is caused by a gene **E** in the presence of **R**. Another cross, New Era (**bE**) $\times$ black (**Be**), however, gave unexpected results. The F_1 seeds were black, and the F_2 segregation took place into black and New Era in a 3 : 1 ratio (the numbers obtained being 644 black and 197 New Era, none of the expected double recessive (**be**) being obtained. In F_3 some black again showed segregation into 3 black to 1 New Era, while the New Era all bred true. From these results, it seems that **B** and **E** behave as though they were allelomorphic to each other, but it may be safely concluded at present that these genes show almost complete repulsion in segregation.

The genes **B** and **E** were also found to produce as one of their effects anthocyanin coloration of the tip of the young pod, calyx and peduncle, though **B** produces a more intense coloration than **E**.

Anthocyanin in Stem and Leaf Stalk. According to the observations of HARLAND (698), most varieties of the cowpea are characterized by dark red color occurring at the junction of the main stem with the petioles and also of the pinnae with the leaf stalk. In other varieties, however, pigmentation is totally absent. Crossing experiments indicated, a monogenic difference between pigmented and unpigmented strains, the former being dominant. The gene was designated as **X**.

Pod Color. In the same place, HARLAND reports that the purple color of the pod is dominant to its absence, depending on a main gene **P**. But the segregation took place in a ratio 3.9 : 1 of purple to non-purple in F_2 and a very similar ratio of 4 : 1 in heterozygous F_3 lines. The marked deficiency of the recessives suggests that more than one gene may be involved. The gene **P** also causes coloration of the tip of the young pod, calyx and peduncle, similar to that caused by the genes **B** and **E**.

Size of 'Eye'. SPILLMAN (204) published a paper on the inherit-

ance of the 'eye' pattern on the seed coat, dealing with the following forms :

1) Small eye. This type varies considerably in the extent of its pigmented pattern, from that of a pigmented spot on each side of the hilum to an area covering about $\frac{2}{5}$ of the ventral surface of the seed.

2) Holstein eye. In this type, the pigmented area covers the microphylar end of the seed, and small spots of pigment are present on the non-pigmented area.

3) Large eye. The pigmented area covers nearly the whole ventral surface, and has a characteristic notch at the microphylar end.

4) Watson eye. This pattern is similar to the Holstein eye, although genetically distinct from it. The pigmented area is present around the hilum with an indistinct margin at the microphylar end of the seed ; the microphylar end is covered with fine dots of pigment.

In crosses between solid black cowpeas and the variety Black Eye, SPILLMAN found in F_2 Holstein and Watson eyes in the ordinary dihybrid ratio. Large eye was regarded as the heterozygotic character between Holstein and Small eye. A similar result was obtained by HARLAND (626), who formulated the scheme of genes as follows :

$D^W H$	 Solid,
Dh	 Watson eye,
dH	 Holstein eye,
dh	 Small eye.

It was further found (698) that the albino type Para carries both **D** and **H**, but is unpigmented owing to its lacking **R**. This was ascertained from the cross of Para with Solid Black which gave in F_2 of the colored types Solid, Watson, Holstein and Small eye in the normal 9:3:3:1 ratio. From these results it is clear that both **D** and **H** produce no visible effect in the absence of **R**. Hence the Solid and Watson varieties may have dark flowers, while the others may be either pale- or white-flowered.

In a still later publication (907), HARLAND described a new pattern 'very small eye'. This type, when crossed with the ordinary Small eye, gave in F_2 9 Watson to 3 Small eye to 4 'very small eye'. The genic constitution of this type was assumed to be **Dy** or **dy**, while Watson is **DY** and Small eye **dY**.

On the other hand, SASAKI (951) reports still another kind of eye, called 'Yakko' No. 1 and No. 2. In these strains the pigmented area is

1) SPILLMAN's gene '**W**' is synonymous with HARLAND's '**D**'.

larger than in the Large eye, but much smaller than in the Holstein. 'Yakko' proved to differ from the Solid type by a single recessive gene. This type was also produced in F_2 from a cross between a Small-eyed strain and a certain Solid type.

Resistance to Disease. Most varieties of cowpeas are more or less attacked by root-knot (*Heterodera radiculicola*, a nematode) and wilt (*Neocosmospora vasinfecta* var. *tracheiphila*, a fungus). The variety, known as the Iron cowpea is resistant to both of these diseases. ORTON (192) showed that this disease resistance behaves as a dominant character. In F_2 a range of variations appeared as to this character.

*Linkage Relations.*¹⁾ HARLAND (626, 698) found that the genes **B** (black pattern of seed coat), **P** (purple pod) and **E** (New Era pattern of seed coat) are linked together. The relation between **B** and **E** has already been given (See under 'Color of Seed Coat Pattern'). The relation of **B** and **P** was investigated in the **Bp** × **bP** cross. This cross gave in F_2 the following results: 168 **BP**, 40 **Bp** and 65 **bP**. The non-appearance of the double recessive **bp** was also observed in F_3 .

As to these three genes the author then concluded, although with reserve, that:

- 1) The genes **B** and **E** show repulsion on a basis probably higher than 1 : 15.
- 2) The genes **B** and **P** show repulsion probably on a basis higher than 1 : 7.

Viola

(Wild Species). BRAINERD (60, 71, 128, 221, 276) identified more or less definitely several allelomorphic pairs in many wild species of *Viola*, e.g. *V. affinis*, *V. cucullata*, *V. pedatifida*, *V. sororia*, *V. papilionacea*, etc. The main results obtained were as follows:

- 1) Seed color. Black and brown are dominant to yellow, and black is apparently dominant to brown.
- 2) Capsule color. Purple proves to be almost completely dominant to green.
- 3) Pubescence of capsule. Pubescence behaves as a dominant to glabrousness.
- 4) Leaf form. Undissected leaves are partially dominant to dissected leaves.

1) The haploid chromosome number in *Vigna sinensis* is 11. (Vide TISCHLER, loc. cit.)

5) Leaf form. Broad cordate leaves behave as a partial dominant over lanceolate leaves.

Besides these clear segregating characters, there were several characters of a more complex nature. They were leaf-size, erectness of plant, color of flower, size of capsule and size of seed.

(Cultivated Species). KRISTOFFERSON (354, 1046) published papers on the cross between *V. tricolor* and *V. arvensis*. Several characters differentiating these species were investigated up to the F_2 generation.

Flower Color. Violet-flowered *tricolor* is dominant to light-yellow *arvensis*. The F_2 segregation took place into 9 violet : 3 blue : 3 red : 1 light yellow. The two genes involved were symbolized as **B** for blue, and **R** for red. When both are present, the petals are violet; when neither is present, they are light yellow.

As to the dark yellow honey-guide, it was found to be of the same appearance in the parental lines and in F_1 of this cross. But in F_2 some plants were obtained with the whole of the spur-petal of the same dark yellow color as that of the honey-guide. The ratio was about 15 plants with small honey-guide to 1 plant with the whole of the spur-petal dark yellow. Two genes, **A** and **B**, were assumed, both being inhibitors and each of these being present in each parent.

Green Spot of Style. The presence of a dark green spot on the front of the style is dominant to its absence, depending on a single gene, **S**.

Floral Construction. The hercogamous form of *tricolor* is usually dominant to the autogamous of *arvensis*. But the segregation did not take place by the monogenic scheme, for hercogamy was found to depend on several morphological characters, such as the development of the labellum, the direction of the opening of the stigmatic chamber, and the nature of the pollen-sac, which behaved independently of each other in F_2 .

Size of Petal. The small flowering type was found to be dominant to the large one. When a large flowering was crossed with another large flowering, the largest flowers were more or less dominant. The F_2 plants of the first mentioned cross showed a continuous variation, and most of the petals had a size of petals approaching that of the small flowering parent.

It was also recorded that small type of the labellum was usually dominant to large.

Chlorophyll Deficiencies. The *albomaculata* form (white-spotted leaves) which was observed in *V. arvensis*, was a simple recessive character.

Height of Plant. Types with different heights gave an intermediate F_1 when crossed. A range of variation was obtained in F_1 .

Habit of Growth. A type with erect main axis and erect branches was crossed by a type with prostrate axis and branches. The F_1 plants were intermediate, and in F_2 a continuous segregation was shown.

Vitis vinifera

Skin Color. STUCKEY (658) found a correlation between grape skin color and vine color; vines having red or reddish green tendrils bear black or reddish black grapes, while those with green tendrils are associated with light or amber-colored fruit.

Inheritance of skin color is well illustrated by studies at the Geneva Experiment Station by ANTHONY (324) and HEDRICK & ANTHONY (403). TABLE XXXVI presents the results of crossing for skin color published by later authors.

TABLE XXXVI.—INHERITANCE OF SKIN COLOR IN GRAPES.
After HEDRICK & ANTHONY (403).

Contrasted colors	F_1			
	Black	Purple to dark red	Medium to light red	White
White—white				166
Light red—light red	8	6	13	8
Dark red—dark red	38	43	45	42
Black—black	407	49	13	54
White—dark red	5	44	14	50
White—black	41	3	3	12
Black—dark red	100	52	40	32

From these data it is clear that most varieties are heterozygous for color and that white is recessive to both black and red. Similar results were obtained also by STUCKEY (658). On the other hand, RASMUSON (461) observed a clear Mendelian segregation. The cross, red $\times$ white, gave black F_1 and a ratio of 9 black : 3 red : 4 white in F_2 . According to him, the genic scheme may be represented as :

AB pure black,
 Ab pure red,
 aB } pure white.
 ab }

Autumnal Coloring. RASMUSON (461). Autumnal coloration of leaves is either red or yellow. . White and red-berried varieties of *vinifera* and all varieties of *Riparia* and *Rupestris* are characterized by yellow coloration, while blue-berried varieties by red. Red is dominant to yellow, giving a monogenic segregation in F_2 .

Pubescence of Canes. RASMUSON (461) also found that all varieties of *Rupestris* and most of *Riparia* have glabrous internodes. This character proved recessive in crosses with pubescent varieties, showing the monogenic scheme of segregation in F_2 .

Variation. In the same paper, RASMUSON also described two cases of variegation, one having green leaves with white or pale yellow spots, and the other green with yellow stripes. Both of these proved recessive to the normal green, giving a monogenic segregation in F_2 .

Resistance to Disease. RASMUSON (461). Resistibility to *Prasmopara viticola* is recessive to susceptibility to the same. Resistibility to *Phylloxera vastatrix*, however, is dominant to its susceptibility, giving segregation in F_2 in a ratio approximating 9 : 7. (also BÖRNER, 329).

Self-sterility. ANTHONY (324) and HEDRICK & ANTHONY (403). Grape stamens are of two types, one having upright filaments and the other having the filaments bending backward and downward soon after the calyx cap falls off. The stamen type seems to be correlated with self-fertility and self-sterility. Plants with upright stamens are self-fertile, while reflexed stamens are always correlated with self-sterility, though in both cases possibly in varying degrees. They found that reflexed $\times$ reflexed gave upright and reflexed in a ratio of 1 : 1, reflexed $\times$ upright gave again a 1 : 1 ratio, and in upright $\times$ upright the ratio was 4.3 upright : 1 reflexed.

Other Characters. In the same publications, ANTHONY also records some observations on size and form of berry and time of ripening. The oval shape of many *vinifera* grapes is probably recessive to the roundness of most American grapes, and oblateness is probably recessive to round. As to the other two characters, no apparent indication of dominance of any type was obtained.

Zea Mays

COLOR (ANTHOCYANIN) INHERITANCE

Aleurone. The anthocyanin pigment in the aleurone layer may be either purple or red, both including various shades. Some earlier experiments on the inheritance of aleurone color have been made by

CORRENS (10) and LOCK (63). They worked with the cross, blue (purple) $\times$ white, and found the dominance of blue, though the degree of dominance showed some irregularity.

EAST & HAYES (165) published more extensive work. They dealt with a variety having red pigment in the aleurone layer, and found that the formation of this pigment is due to the co-operation of two genes **C** and **R**. Moreover purple is dominant to red, being due to a single gene **Pr**. There is also a fourth gene **I**, an inhibitor suppressing all colors no matter if all the dominant color genes are present. Later, EMERSON (541) showed that in addition to **C** and **R**, another gene **A** is also necessary for the production of red aleurone. For he obtained in F_2 a 27 : 37 ratio of colored to colorless aleurone. He also discussed various intensities of the aleurone color in different races. Color of the aleurone often is related to color and texture of the underlying endosperm tissue.

Still later, FRASER (1141) found some genetic differences in intensities of colors. Light colors proved dominant to the corresponding dark colors. The gene involved was designated as **In**. The recessive **in** gene gives certain blackish colors when combined with the fundamental aleurone series **ACRi**, together with either **Pr** or **pr**. The dominant gene, **In**, results in light shades of color.

Thus we get the following genic formulae for aleurone color :

ACRPrInI		light purple,
ACRPrini		dark purple,
ACRprInI		light red,
ACRprini		dark red,
ACRPrInI	}	. . colorless.
ACrPrInI		
AcRPrInI		
aCRPrInI		
Any other combinations		

KVANKAN (1180) added another new aleurone color : brown. This color is unrecognizable with the naked eye. To determine whether the aleurone is brown or not, it is necessary to examine sections under the microscope. When brown aleurone was combined with colorless endosperm, the general appearance of a caryopsis is pale yellow. Brown proved dominant to colorless by a single gene **Bn**. It was further shown that the gene pair **Bnbn** is quite unrelated to other genes concerned in

the development of aleurone color. Also the gene pair **li** does not interfere with the full expression of brown aleurone pigmentation.

As to mottling of aleurone color, EMERSON (541) showed that it occurs when the gene **R** is contributed by the male parent and **r** by the female parent of a cross, indicating that colored aleurone of the constitution **RRR** or **RRr** is self-colored, while that of the constitution **rrR** shows mottling. This was confirmed by COULTER (685), who showed that $\text{ccRRPrPr} \times \text{CCrrPrPr}$ gave the purple grains only, while the reciprocal cross $\text{CCrrPrPr} \times \text{ccRRPrPr}$ gave the mottled grains.

EMERSON (541) also described two color patterns which are apparent in homozygous races. They were given the names 'speckled' and 'dark-capped'. The color is restricted to the crown of the grain, and varies from a mere speck to a large spot. Both proved recessive to self-color.

Pericarp. There are numerous expressions of the pericarp colors, i.e. purple, red, cherry, orange, brown and white. CORRENS (10) and LOCK (63) demonstrated that red color in the pericarp is dominant to its absence, forming a simple Mendelian case. EAST & HAYES (165) made a cross between two reddish varieties in which the pigment developed only when exposed to light, and obtained in F_2 red and white in a 15 : 1 ratio, indicating that two separately inherited genes are concerned in the production of this pigment. In some cases the pericarp color may be inherited in a complete association with the color in other organs, as if due to a single gene. Thus examples have been given by EMERSON (166) in which the color in pericarp and cob is correlated in inheritance. The cross of red cob, white pericarp $\times$ white cob, red pericarp, gave in F_1 red cob and pericarp which showed segregation in F_2 into red cob, white pericarp; red cob, red pericarp; and white cob, red pericarp in a 1 : 2 : 1 ratio. These results suggest that the gene for color in the pericarp behaves as an allelomorph of the gene for color in the cob. EMERSON designated the gene for red pericarp color as **P**. The expression of **P** is related to the presence or absence of the gene **A**, as shown in the following scheme :

AP		red,
aP		brown,
Ap	}	white.
ap		

Later, ANDERSON & EMERSON (981) and ANDERSON (1102) published more extensive results, and found that the pericarp colors could be

divided into two categories which are independent of each other in inheritance. They were called the 'red series' and the 'cherry series.'

1) Red series: a series of allelomorphic types characterized by a rather soluble brick-red or orange red pigment. The genic scheme of this series may be represented as:

<i>Genic symbols</i>	<i>Pericarp</i>	<i>Cob</i>
AP^{rr}	red	red,
AP^{or}	orange	red,
AP^{wr}	white	red,
AP^{ow}	orange	white,
AP^{ew}	red (white-capped)	white,
AP^{er}	red (white-capped)	red,
AP^{vv}	variegated (red)	variegated.
AP^{mo}	patched (red)	white.

Any one of these color combinations noted above behaves as a simple allelomorph to any other. For example, WR (white pericarp, -red cob) $\times$ CW (white-capped red pericarp, white cob) gives in F_1 CR and in F_2 , 1WR:2CR:1CW. Likewise, VV $\times$ RR gives RR in F_1 and in F_2 3RR:1VV. When types showing color in different regions are crossed, both regions are colored in F_1 . Thus CW $\times$ VV shows the CW pattern in light-red overlaid by deep-red variegation. It was also verified in several cases that progeny of any hybrid out-crossed to the pure recessive type, WW (white pericarp, white cob), consists of the two parental types only. For example, (WR $\times$ CW) $\times$ WW gives WR and CW in equal numbers. (WR $\times$ VV) $\times$ WW gives WR and VV in a 1:1 ratio.¹⁾

In the above genic formulae, **A** is the same general gene that is fundamental in aleurone and plant color. Therefore the red pericarp pigment (containing **A**) develops on sun-red, dilute sun-red, purple and dilute purple plants. When **A** is absent in the same formulae, brown color replaces the red in both pericarp and cob. Thus **aP^{rr}** results in brown pericarp, brown cob, **aP^{or}** in orange pericarp, brown cob and so on. These plants (containing **a**) are either brown or green.

2) Cherry series: the cherry pericarp color is due to the presence in the pericarp of the water soluble purple pigment (anthocyanin) found commonly in general plant bodies (See also under 'Plant Color').

1) In this case, the WR type appeared in slightly larger numbers than the VV type. This is due to the fact that the genes for variegation (as well as for mosaic and orange) are quite unstable, and crosses involving these types give some mutants (solid red) in the progeny.

The genic scheme of this series may be represented as :

<i>Genic symbols</i>	<i>Pericarp</i>	<i>Plant</i>
APlr^{ch}	cherry	purple or dilute purple,
APlr^{r}	white	purple or dilute purple,
Aplr^{ch} } Aplr^{r} }	. . . white	sun-red or dilute sun-red,
aPlr^{ch}	brownish . . .	brown or green,
aPlr^{r}	white	brown or green,
aplr^{ch} } aplr^{r} }	. . . white	green.

The gene r^{ch} is one of the members of an allelomorphic series of genes affecting aleurone and plant colors. This gene is necessary for the production of cherry color. Other allelogenes of the **R** series, such as r^{r} have not enough activity to produce cherry pericarp color.

Recently, ANDERSON (1235) described another type of brown. This proved to be dominant to the ordinary red color, and was probably due to a single gene. This color belongs to another category of pericarp color, for the gene was found to be independent of the **P** series of allelomorphs. This brown pericarp appeared on dilute sun-red, sun-red, dilute purple and purple plants in contrast to the recessive brown mentioned above.

Aside from these pericarp colors, there are several expressions of variegateds and mosaics. EMERSON (339, 487), showed that medium variegation (P^{mv}) is a simple dominant to very light variegation (P^{lv}). The gene P^{mv} or P^{lv} can change into the dominant condition P^{rr} . The reverse mutation has been also noted, but much less frequently. HAYES (492) and EYSTER (1253) have observed analogous cases for mosaic. Heavy mosaic is a dominant to a light mosaic.

'Plant' Color. Under the name 'plant color' are included the anthocyanin pigments in several external plant organs, such as culm. staminate inflorescence, husks, leaf sheaths and to some extent leaf blades.

EMERSON (778) fully reported the inheritance on this subject. According to his observations, there are five types and four sub-types as to this character, as follows :

5 types : purple, sun-red, dilute purple, dilute sun-red and brown.

4 sub-types : weak purple, weak sun-red, green-anthered purple and green-anthered red.

For the production of sun-red and dilute sun-red, daylight is necessary, while purple and dilute purple may develop in the dark.

A number of crosses between these types and sub-types were fully investigated. The cross of purple with green gave purple F_1 , and in F_2 a ratio of 27 purple : 9 sun-red : 9 dilute purple : 3 dilute sun-red : 9 brown : 7 green. The F_1 plants back-crossed to green gave these six forms in a 1:1:1:1:1:3 ratio, clearly indicating that three genes are concerned in the production of the pigments. These genes are:

A: the basic gene for the production of anthocyanin,

B: a gene for the production of a brown flavone,

Pl: a gene for the production of a purple anthocyanin.

The scheme of these genes may be: **ABPl** purple, **ABpl** sun-red, **AbPl** dilute purple, **Abpl** dilute sun-red, **aBPl** brown, **aBpl**, **abPl** and **abpl** green. Striking confirmations of this assumption were obtained from several crosses, e.g. dilute purple $\times$ sun-red, and brown $\times$ dilute sun-red. The F_1 plants resulting from these crosses have a great amount of the purple pigment.

In addition to these fundamental genes there are two series of genes modifying the color, one being the **B** series, and the other the **R** series. The difference between weak sun-red and dilute sun-red and also weak purple and dilute purple is caused by a gene **B^w**. The genes **B**, **B^w** and **b** constitute a series of multiple allelomorphs. Thus **AB^wPl** is weak purple, and **AB^wpl** weak sun-red. To the multiple allelomorphic series of **R** belong **R^r**, **R^g**, **R^{rg}**, **r^r** and **r^{ch}**. The effect of the **Rr** genes on plant color is indicated by subscripts. The gene **R^{rg}** is assumed to be the causal gene for green anthers and silk in purple, sun-red, dilute purple and dilute sun-red types. **R^g** and **r^g** are assumed to have the same effect on purple and sun-red and to ensure colorless (green) throughout in what would otherwise be dilute purple and dilute sun-red. The **R** series has no effect on brown, except for **r^{ch}**, which intensifies brown as well as purple and dilute purple. As regards plant color only, therefore, **R^r**, **r^r** and **r^{ch}** are dominant to **R^g** and **r^g**, and **R^{rg}** is dominant for plant color except of the anthers and the silk, for which it is recessive. In addition to these, the aleurone genes **C** and **P** were also assumed to exert a modifying effect on certain plant colors.

These complex series of the genes may be arranged as follows:

<i>Genic symbols</i>	<i>Plant</i>	<i>Anthers</i>
ABPIR^r	purple	purple,
AB^wPIR^r	weak purple	purple,
ABPIR^{rg}	purple	green,
ABPIR^g	purple	green,
AbPIR^r	sun-red	pink,
AB^wPIR^r	weak sun-red	pink,
AbPIR^{rg}	sun red	green,
AbPIR^g	sun red	green,
AbPIR^r	dilute purple	purple,
AbPIR^{rg}	dilute purple	green,
AbPIR^g	green	green,
AbPIR^r	dilute sun-red	pink,
AbPIR^{rg}	dilute sun-red	green,
AbPIR^g	green	green,
aBPIr^{ch}	intense brown	green,
aBPI(R)	brown	green,
aBpl(R)	} green green.	
abPI(R)		
abpl(R)		

As to the color in the silk, ANDERSON (753) described salmon and brown silks which differ from green by a single gene, Sm , green being dominant. The gene A was found to be necessary to produce salmon or brown silk color. The intensity of pigmentation of these colors is related to that of the pigmentation of the pericarp. The relations of the genes A , Sm and P to silk color may be given thus:

ASmP	} green,
ASmp	
AsmP	salmon,
Asmp	brown.

When A is absent, all the silks are green.

Recently, JENKINS (1275) described a new character called purple plumules, in which the pigment is confined to the plumule sheath or coleoptile in the embryo of the seed. This character proved dominant to colorless, depending on a single gene, Pu . Pu is a gene for plant color in the embryonic plant.

ENDOSPERM CHARACTERS

Endosperm Color. The endosperm of maize may be either yellow or white. That in general yellow is a simple dominant to white or colorless, is clear from studies by several investigators, viz. CORRENS (10), LOCK (63), EAST & HAYES (165), HAYES (238), COLLINS (277) and others. The dominance of yellow, however, is not always complete, and moreover reciprocal crosses between white and yellow give different shades of yellow. These results may be explained on the assumption of the effect of the triple fusion of nuclei ($2 \text{♀} + 1 \text{♂}$), that is, the color is modified by the number of doses of the yellow gene **Y** (EAST & HAYES, 165). Thus:

YYY.		dark yellow,
YYy.		yellow,
Yyy.		light yellow,
yyy.		white.

EAST & HAYES (165) also recorded the results of other yellow-white crosses which may be explained by two (giving 15 yellow : 1 white in F_2) or three (giving 63 yellow : 1 white in F_2) multiple genes.

On the other hand, WHITE (516) observed a dominant white in a cross, yellow California gold pop maize $\times$ white Caragua-maize. It was assumed that the white variety possessed **Y** and also an inhibitory gene, **A**, while the yellow variety carried **Y** but lacked **A**.

Recently, ANDERSON (1236) described a light or pale yellow endosperm which is genetically independent of the gene **Y**. The gene involved was designated as **Yp**. He found also a dominant white, as did WHITE (516). To this gene has been now given the designation **Wh**. Plants containing **Wh** are imperfectly dominant to both deep and pale yellow.

Endosperm Texture. There are several conditions in the endosperm texture. The soft or flour corns are characterized by a soft starchy endosperm occupying the entire seed outside of the embryo. In dent corns the corneous starch is located in the sides of the seed, and the soft starch extends to the summits. The flint corns have soft starch surrounded by corneous starch, the proportions of soft and corneous starch varying considerably in different varieties. In the pop corns, there is hardly a trace of the soft starchy endosperm, almost the entire seed being corneous-starchy. This group is characterized by the small size of its

seeds and ears. In the waxy corns, a waxy endosperm occupies the same position as does the corneous endosperm in the pop varieties, and surrounds a very small soft starchy portion. The so-called sweet corns are dent, flint or pop varieties which lack the ability to mature starch normally. Their seeds shrink in drying, and take on a glassy appearance.

The cross between the waxy variety of Chinese maize and American sweet varieties has been reported by COLLINS & KEMPTON (164, 334) and KEMPTON (640). The F_1 endosperm was corneous, and in F_2 a ratio of 9 horny to 4 sweet to 3 waxy seeds was obtained. Two genes Su and Wx were assumed, their relations being as follows:

<u>Su</u> <u>Wx</u>		starchy,
<u>Su</u> <u>wx</u>		waxy,
<u>su</u> <u>Wx</u>	}	sugary.
<u>su</u> <u>wx</u>		

In this F_2 generation, however, a marked deficiency of waxy seeds, larger than as it could reasonably be ascribed to chance, was observed by these investigators. BRINK & MACGILLVRAY (1113) and BRINK (1238) made further studies on this subject, and concluded that the deficiency is due to a lower rate of growth of the pollen tubes carrying the waxy gene.

LAMPE & MEYERS (1182) published brief notes on the mode of expression of these genes on carbohydrate storage. The presence of both genes Su and Wx is necessary for the development of the large simple starch grains. The absence of Su results in the development of the globules and the compound nature of the larger grains. The absence of Wx conditions the development of the grains which with iodine stain red instead of blue.¹⁾

The sweet-starchy cross has been made by several workers, viz. CORRENS (10, 16), LOCK (63), EAST & HAYES (165), HAYES (238) and others. The difference proved to be due to a single main gene, the starchy condition being dominant. HARPER (702) on the other hand reported a case of a cross between two sweet varieties which gave pure starchy F_1 seeds, in appearance.

1) According to BRINK & MACGILLVRAY (1113), DEMEREC (1127) and LONGLEY (1288), plants heterozygous for the waxy character produce two sorts of pollen in approximately equal proportion, one staining blue with iodine, and the other red. A similar segregation in sporogenesis has been found in embryosacs of Wxwx plants by BRINK (1238). On the contrary, KIESELBACH & PETERSON (1279) obtained results indicating that these differences should not be interpreted as segregation. According to them, all mature pollen gave the blue reaction with iodine, while all immature pollen stained reddish.

Certain races of starchy and sweet maize, when crossed, showed a marked deficiency of the recessives in F_2 . According to studies by JONES (1161) and EMERSON (1133), this is explained by the assumption that the fertilization takes place more frequently with the 'starchy' pollen than with the 'sweet' pollen.

A new form of endosperm called pseudo-starchy, which is often present in some sweet corn ears, has been described by JONES (634). This form may be considered to be an intermediate condition between true starchy and sweet endosperm. The cross of pseudo-starchy and true starchy maize gave F_1 seeds exactly the same as when sweet and starchy are crossed, and in F_2 clear-cut segregation into 3 starchy to 1 sweet was obtained. But when this type was crossed with sweet maize, the result was different in the reciprocal crosses. Using this type as the female parent, the F_1 seed results in pseudo-starchy, while its reciprocals give sweet maize. The results were explained on the assumption of three genes, **M**, **N** and **O**.¹⁾ Their activities are as follows:

M: a plant gene necessary for the full expression of pseudo-starchiness.

N: an endosperm gene which prevents the characteristic shrinking of sweet seeds.

O: an endosperm gene which determines opaqueness.

The genes **M** and **N** are cumulative in effect, whereas **O** is not, showing complete dominance. **N** in addition has a greater effect when coming from the female side than from the male. According to this assumption:

Plant seed

MM NNOO = pseudo-starchy,

mm nnoo = sweet.

The reciprocal crosses give:

Plant seed

MM NnOo = pseudo-starchy ♀ × sweet ♂,

mm nnOo = sweet ♀ × pseudo-starchy ♂.

In the first cross the double dose of **N** and the determining nature of **O** prevent any noticeable wrinkled or translucent effect appearing. In the reciprocal cross, however, the single doses of **N** and **O** are non-effective in the absence of **M**.

The relationship of flour to flint has been elucidated by HAYES & EAST (402). Reciprocal crosses between these strains gave different results. Flour ♀ × flint ♂ gave flour; flint ♀ × flour ♂ gave flint. The

1) The original symbols of these genes are **A**, **B** and **C** respectively.

maternal type of grains was always produced in such reciprocal crosses. In F_2 , however, both the F_1 grains gave the same distinct segregation into flour and flint grains in a 1 : 1 ratio. These results were most easily explained by the cumulative effect of a single gene, **Fl**; thus :

$$\begin{array}{l} \begin{array}{c} \text{FIFIFl} \\ \text{FIFIfI} \\ \text{fIfIFl} \\ \text{fIfIfI} \end{array} \left. \vphantom{\begin{array}{c} \text{FIFIFl} \\ \text{FIFIfI} \\ \text{fIfIFl} \\ \text{fIfIfI} \end{array}} \right\} \dots \dots \dots \text{flint,} \\ \begin{array}{c} \text{fIfIFl} \\ \text{fIfIfI} \end{array} \left. \vphantom{\begin{array}{c} \text{fIfIFl} \\ \text{fIfIfI} \end{array}} \right\} \dots \dots \dots \text{flour.} \end{array}$$

The inheritance of dent, flint and pop endosperms has been studied by HAYES & EAST (165, 402) and HAYES (238). Dents crossed with flint races gave the F_1 of a uniform nature and intermediate in appearance. Segregation occurred in F_2 ; some forms were obtained in F_3 which bred true to the flint type, some bred true to the dent type, while still others showed segregation. Somewhat similar results were obtained also in the pop-flour and dent-flour crosses. These results may be explained in terms of quantitative inheritance.

Chemical Composition. PEARL & BARTLETT (193) made a cross between a white sweet race (♂ parent) and a yellow dent starchy race (♀ parent). Determinations were made by direct analysis of the percentage content of the grains of the pure parental races and the F_1 and F_2 progeny in respect to several chemical constituents. The results were as follows :

Character	Dominant	Recessive
a) Moisture	High content	Low content.
b) Nitrogen and protein	Low	High „
c) Crude fat	Low	High „
d) Ash	Low	High „
e) Crude fiber	Low	High „
f) Pentosans	Low	High „
g) Sucrose	Low	High „
h) Dextrose	Low	High „
i) Starch	High	Low „

The inheritance of high and low protein content has been rather extensively investigated. This character was found to be influenced largely by environmental conditions; variations as high as 40 per cent being caused by them. EAST & JONES (688) showed that the percentage protein content of the grains of an F_1 ear frequently corresponds closely to that of the lower-protein parent. Thus lower-protein content appears

to be dominant to higher. It was also demonstrated by HAYES & GARBER (629) that F_1 ears of crosses between self-fertilized high-protein races have considerably lower percentage protein content than the parental self-fertilized line. There was also a certain correlation between the number of grains and the protein content. A small number of grains per ear was found to be correlated with high protein content.

Recently, LINDSTROM & GERHARDT (1190), from a cross involving Iodent (yellow dent) and Evergreen (white sweet corn), confirmed some of the results obtained by PEARL & BARTLETT. High sugar and dextrin and also low starch were found to be distinctly recessive, although there is a small cumulative effect of the genes caused by the triple fusion of nuclei. No such effect was found with respect to fat, the reciprocal hybrids being identical and intermediate in percentage but with a slight tendency toward the dominance of low fat.

Defective Endosperm. Defective seeds, in which the endosperm is lacking or is incomplete or abnormal in its development, have appeared in nearly all the varieties of maize. There are a number of different types of the defective endosperm, i.e. mealy endosperm in which the corneous portion of the endosperm is partially or completely lacking (MANGELSDORF, 935, 1055), sweet defective and flint defective (LINDSTROM, 1051; WENTZ, 1326) and other several instances (JONES, 709; GARBER & WADE, 1143; WADE, 1320). In these cases the grains are slightly or considerably smaller in size than the normal. All of them proved to be recessives to the normal endosperm. Intercrosses of many of these types gave normal grains in F_1 .

In some the embryo is entirely lacking — 'germless seeds' as they are called by DEMEREC (1000). This type gave 63:1, 15:1, 3:1 and 9:7 ratios, indicating the presence of at least four genes for germless, three of them being triplicate genes.

Several other types, i.e. 'shrunk endosperm' (HUTCHISON, 795) in which the endosperm fails to develop completely, often leaving a hollow space near the center of the grain, 'scar' (EYSTER, 894) which appears as an irregular crater-like cavity in the endosperm on the abgerminal side near the crown of the kernel, and 'miniature germ' (WENTZ, 1231) in which the embryo is very small and there is a very small germ area, all proved to behave as simple recessives to the normal. The corresponding recessive genes have been symbolized as sh for 'shrunk endosperm' sc for 'scar' and mg for 'miniature germ'.

EAR AND TASSEL CHARACTERS

Pod Ear. EAST & HAYES (165), COLLINS (484), JONES & GALLASTEGUI (635), EYSTER (782, 892). In the pod corns (*Zea tunicata*), each grain is enclosed entirely by the glumes. The tassel (staminate inflorescence) is also characterized by extraordinarily large and thick glumes. This character proved heterozygously dominant to the normal, and when selfed, gave three types of plants: (1) like the parent; (2) with normal ears; (3) with greatly enlarged tassels containing both staminate and pistillate flowers, and with the ear either aborted or bearing greatly enlarged and usually sterile spikelets. The last type is the homozygous dominant, but is almost lethal as far as reproduction is concerned. The gene concerned was designated as **Tu**.

Teopod Ear. LINDSTROM (1287). A character called 'teopod' has two outstanding characteristics: (1) grains covered with long glumes like pod corn; (2) extremely narrow leaves, suckering habit of growth, and wax on the stalks, like teosinte. The lower flowers are often completely sterile. Teopod behaves as a simple dominant in inheritance. The gene symbol is **Tp**.

Ramosa Ear. COLLINS (484). In this type (*Zea ramosa*), the ear is profusely branched, normal grains being borne on the branches. The tassel is also characterized by the lateral branches growing up the main spike in the form of a spruce tree even to the very tip. Ramosa ear proved to be a simple recessive to the normal. The gene was symbolized as **ra**. The relationship of the pod to the ramosa type may be represented as:

tuRa		normal,
TuRa		pod,
Tura		pod ramosa,
tura		ramosa.

Though the ramosa is a simple recessive to the normal, its segregates undergo alternations, retaining partially the characteristics of the normal, while conversely the normal plants show the effect of their ramosa ancestry.

Branched Ear. KEMPTON (1039). This is another type of the branched ear variation, and is characterized by from one to many quadrifurcate branches at the base of the ear, usually with fully developed grains. This character seems to be recessive to the normal.

Fasciated Ear. Some earlier observations had been made by HUS & MURDOCK (178), who regarded fasciation in the ear as a non-inherited character. According to EAST & HAYES (165), however, this character is determined largely by genetic conditions, although soil and climatic factors have considerable influence on the expression of fasciation. Fasciation was found to be a dominant character. Later EMERSON (227), on the contrary, reported that this character behaves as a recessive and shows segregation in F_2 in a 3:1 ratio. In some strains, EMERSON found that perhaps two genes were concerned.

Silkless Ear. JONES (1276). The ear is barren of silk, and no grains are produced, apparently due to an abnormal development of the ovules. Pollen production is not noticeably affected. This type proved to be a simple recessive. The gene symbol is sk.

Tassel Ear. EMERSON (689). In this type, an ear-like structure develops in place of the tassel, and mature grains may be formed on it. This character is a simple recessive to the normal. The gene symbol is te.

Tassel Seed. EMERSON (689). This type resembles tassel ear, but the inflorescence is much looser. In rare cases staminate flowers develop along with the pistillate ones, but they are probably not functional. Tassel seed proves also recessive. The gene symbol is ts. Crosses of the two types (through the heterozygous condition) were always found to give normal plants.

Adherence. KEMPTON (715). The upper leaves adhere as if glued, and the branches of the tassel are compacted into a hardened mass. Extremely adherent plants are characterized by abnormal growth or contortion of the culm. Adherence is often recognizable in the seedling stage. This character is also recessive. The gene was designated as ad.

Male-Sterility. EYSTER (781). Failure of plants to produce pollen is called male-sterile. This character is conditioned by a single recessive gene, ms.

OTHER MORPHOLOGICAL CHARACTERS

Dwarfishness. There are several forms of dwarfishness, all of which proved to be simple recessives to the normal type. They are as follows:

- 1) True dwarf (dd)¹⁾. EMERSON (227, 888). The plant averages

1) The letters in the brackets represent the genic composition.

only about 30–40 cm. in height, whereas the normal type is 2 meters or more high. The plant is also andromonoecious.

2) Brachytic type (brbr). KEMPTON (713, 714, 802, 1041). This type is the result of a shortening of the internodes, and is to be distinguished from the above mentioned dwarf type. Analogous cases are found in 'bush' peas, beans, tomatoes and other plants. The cross, Brd × brD, gives normal plants in F_1 and in F_2 normal (BrD), brachytic (brD) and dwarf (Brd, brd) plants in a ratio of 9:3:4, indicating that the double recessive closely resembles the true dwarf type.

3) Anther ear (anan). EMERSON (888). This is also andromonoecious, but is slightly taller than the true dwarf. Intercrosses between dAn and Dan give normal plants in F_1 and normals, dwarfs, anther ears and dwarf anther ears in F_2 in approximately a 9:3:3:1 ratio.

4) Nana type (nana). According to LINDSTROM (1052), this type, crossed with any of the other dwarf types, gives normal plants in F_1 , showing a segregation in F_2 into normals, parental types of dwarfs and new combinations of the two dwarfs in the double recessive.

Zigzag Culms. ETHERIDGE, EYSTER & STADLER (891), EYSTER (692, 893). Corn plants with zigzag culms were first observed in F_4 progenies of Tom Thumb pop corn × a Missouri dent corn. This type is more or less crooked instead of straight as in the normal type. Crosses between normal plants and zigzag plants gave F_1 with normal culms, which gave some F_2 progenies consisting of normal plants and zigzag plants in a ratio of 15:1 and others 3:1. Two duplicate genes, Z and Zg were assumed for normal growth, the double recessive condition, zzg, resulting in zigzag stems.

Leaf Abnormalities. There are several abnormal variations in the leaves. All are recessive to the normal leaf.

1) Liguleless leaf (lglg). EMERSON (228). The absence of ligule is associated with the absence of auricle. These two conditions may be due to a single gene.

2) Crinkly leaf (crclr). EMERSON (778). The plant is a semi-dwarf, usually about $\frac{2}{3}$ the height of normal plants, with crinkled leaves and relatively short and compact tassels. This type was found in F_2 of a cross between dent and flint corn strains.

3) Dead leaf margins (dlldl). KEMPTON (1040). The upper 6 to 8

blades embrace a leaf or two below the ear-node. This character becomes noticeable about the time the tassel appears but before the flowers are mature.

4) Twisted seedlings (twtw). KVANKAN (1283). The character shows in the very earliest stage of the growth of the seedling in a pronounced twisting of the first leaves. Three types of twisted seedlings are found, which are genotypically different from one another; tw₁, tw₂ and tw₃. Intercrosses of these three types give the normal F₁ plants.

Chlorophyll Deficiencies. Numerous chlorophyll defects have been found in the seedling or mature plant phases of corn. Most of them prove to be simple recessives to the normal green.

1) Albino seedlings (ww). EMERSON (227), MILES (414), BACH (673), DEMEREC (999), LINDSTROM (561, 810, 1189), DEMEREC & EMERSON (1129). Albino seedlings are characterized by the complete failure of chlorophyll (not by the lack of plastid), the seedlings perishing within 2 or 3 weeks time. Intercrosses through the heterozygous condition showed that there are involved at least 10 genes for white seedlings, w₁—w₁₀ (DEMEREC & EMERSON). Five of them are simple Mendelian genes which are independently inherited, four of them form two sets of duplicate genes, and probably at least one additional gene can be obtained from a set of triplicate genes.

2) Virescent seedlings (vv). LINDSTROM (561, 718, 810), DEMEREC (1126, 1128), STROMAN (1217). The seedling appears white at first, but under favorable conditions it gradually gets a yellowish green color, especially at the tips of the leaves, so that the plant may mature although it would be very small and weak. DEMEREC recognizes the existence of five genetically different types of virescent to which he assigns the symbols v₁ to v₅. The double recessive condition is somewhat lighter than either parent type.

3) Yellow seedlings 1 (ll₁). LINDSTROM (501, 561, 810, 1189). The yellow color in this type is due to a distinct yellow pigment (xanthophyll and carotin), the normal green component of chlorophyll being suppressed. The yellow seedlings die before maturity. The relationship between L₁, V₁ and W₁ may be shown as:

<u>L</u> ₁ <u>V</u> ₁ <u>W</u> ₁	}	 green,
<u>l</u> ₁ <u>v</u> ₁ <u>w</u> ₁		
<u>L</u> ₁ <u>v</u> ₁ <u>W</u> ₁	 virescent-white,	
<u>L</u> ₁ <u>V</u> ₁ <u>w</u> ₁	}	 white,
<u>l</u> ₁ <u>v</u> ₁ <u>w</u> ₁		

$l_1v_1W_1$		virescent yellow,
$l_1V_1w_1$	}	 pure yellow.
$l_1v_1w_1$		

4) Yellow seedlings 2 (l_1l_1). LINDSTROM (1285). The seedlings are distinctly of deeper color than those produced by the gene l_1 . Where l_1 interacts with each of the three albino-genes w_1 , w_2 and w_3 so as to give a 12:3:1 ($L_1W + l_1W : L_1w : l_1w$), the gene l_2 exhibits a 9:3:4 relation ($L_2W : l_2W : L_2w + l_2w$).

5) Golden (gg). EMERSON (227, 229), MILES (414), LINDSTROM (561). In this plant, when a month or more old, the green color begins to disappear, leaving a distinct yellow pigment. It may mature, though not very vigorously, and produce small ears.

6) Pale green 1 (pg_1pg_1). BRUNSON (1115). This type is a lethal seedling character having about 15 per cent of the normal chlorophyll and about 50 per cent of the normal xanthophyll content.

7) Pale green 2 (pg_2pg_2). DEMEREC (1128, 1247). This type has about 53 per cent of the normal chlorophyll and practically normal xanthophyll content. It is very variable in color with extreme variations which can hardly be distinguished from normal green seedlings. Under favorable conditions it may reach maturity. Mature plants are green and indistinguishable from normal plants.

8) Pale green 3 (pg_3pg_3). DEMEREC (1128, 1247). The plant has about 30 per cent of the normal chlorophyll, but the xanthophyll content is practically normal. It perishes in the seedling stage.

9) Pale green 4 (pg_4pg_4). DEMEREC (1128, 1247). This type is slighter green than pale green 3, having 40 per cent of the normal chlorophyll content. The xanthophyll content is not different from that in normal green seedlings. All plants of this type die in the early seedling stage.

10) Pale green 5 (pg_5pg_5). DEMEREC (1128, 1247). This type is still another lethal seedling character having 70 to 80 per cent of the normal chlorophyll. In the early seedling stage it can hardly be distinguished from the green seedlings. The xanthophyll content is normal.

11) Xantha 1 (xn_1xn_1). TRAJKOVICH (1222). The plant has only about 10 per cent of the normal chlorophyll. The xanthophyll content is normal. When grown under favorable conditions, it may mature and produce a tassel and grains. Crosses with the virescent type showed that

the double recessive condition, virescent-xantha, is not phenotypically distinct from the virescent.

12) Xantha 2 ($\underline{\mathbf{xn}_2\mathbf{xn}_2}$). DEMEREC (1128, 1247). This type closely resembles xantha 1, and has practically the same amount of chlorophyll and normal xanthophyll content.¹⁾

13) Yellow-white ($\mathbf{mm}$). STROMAN (1218). This type is found only in the seedling stage. The seedlings appear more or less green at first, but they turn yellow and white very soon, and die before maturity. The expression of this type is due to two loosely linked genes $\mathbf{m}_1$ and $\mathbf{m}_2$. In crosses involving $\mathbf{m}_1$ (or $\mathbf{m}_2$) and $\mathbf{w}_2$ (an albino-gene), it was found that when $\mathbf{w}_2$ is homozygous, complete albinism results, even in the presence of $\mathbf{m}_1$ (or $\mathbf{m}_2$).

14) Zebra seedlings ($\underline{\mathbf{zb}_2\mathbf{zb}_2}$). STROMAN (1218). This resembles very closely the mature-zebra type. (See *Chloroph. Defc.* No. 19). The seedling-zebra character, however, is apparent only in the seedling stage.²⁾

15) Japonica ($\mathbf{jj}$). MILES (414), LINDSTROM (561), EYSTER (892). There are two distinct types of japonica striping, one having the leaves exhibiting longitudinal stripes of green and white color, and the other showing stripes of green and yellow. The difference is due to the $\mathbf{L}_1\mathbf{l}_1$ gene pair. $\mathbf{L}_1\mathbf{L}_1\mathbf{jj}$ results in white-striping, while $\mathbf{l}_1\mathbf{l}_1\mathbf{jj}$ produces yellow-striping.

16) Green-striped ($\underline{\mathbf{gsgs}}$). MILES (414), EMERSON (227, 229), LINDSTROM (561), EYSTER (892). This type is characterized by narrow, definite and alternate stripes of dark and light green throughout the leaves. The mature plants are less vigorous than normal green plants. The character does not manifest itself in the early stage; it appears about two months after germination.

17) Yellow-striped ($\underline{\mathbf{ysys}}$). LINDSTROM (1051). The striping pattern is identical with that of the green-striped. The alternate stripes, however, are green and yellow.

18) Fine-striped ($\mathbf{ff}$). LINDSTROM (561). This type is characterized by fine stripes or streaks of white ($\mathbf{L}_1\mathbf{L}_1\mathbf{ff}$) or yellow ($\mathbf{l}_1\mathbf{l}_1\mathbf{ff}$).

1) Intercrosses between these several green types : $\mathbf{pg}_2$, $\mathbf{pg}_3$, $\mathbf{pg}_4$, $\mathbf{pg}_5$ and $\mathbf{xn}_2$, were made by DEMEREC (1247). The F_1 generation in all possible combinations was normal-green. Nine crosses of them were carried to F_2 , and gave a 9 : 7 ratio in each case.

2) DEMEREC (1128) briefly noted that intercrossoes suggested the existence of 4 different genes for zebra seedlings ($\underline{\mathbf{ze}_1-\mathbf{ze}_4}$)

19) Zebra-striped (zb₁zb₁). DEMEREC (775). This type has transverse stripes made up of numerous yellow dots on the leaves which become more pronounced on the mature plants.

20) Fine-streaked (fifi). ANDERSON (863). This character closely resembles fine-striped in appearance, but is genetically different (See under 'Linkage Relations').

21) Lineate (lili). COLLINS & KEMPTON (681). Lineate plants show a fine white narrow striping on the blades of the upper leaves beginning at about the tenth.

22) Dotted (dt₁dt₁). LINDSTROM (561). Dotted or spotted leaf is characterized by numerous dots on the leaves.

23) Blotching (bl₁bl₁). EMERSON (1002). Blotch leaf is characterized by the presence of blotches of a yellowish color; principally on the leaves, a considerable part of the tissue usually dies.

24) White sheath (ws₁ws₁). KEMPTON (804). In this type the leaf-sheaths and husks fail to develop chlorophyll and remain white.

25) Polkadot (pk₁pk₁). EYSTER (1136). The plants are normal green until about the time the tassel makes its appearance, when the margins of the leaves gradually become yellow. The yellow color spreads inwards towards the midrib, and within these areas are small spots of green tissue, producing the polkadot pattern.

26) Jojap (ij₁ij₁). JENKINS (1160). This new type of striping in many of the mature striped plants resembles japonica striping. Jojap striping appears in the seedling stage, while japonica striping does not.

27) White-base (wl₁wl₁). STROMAN (1218). White-base leaf is most recognizable in half-grown plants. Near maturity the white color at the base gradually spreads outward into the leaf blade giving a mottled or striped appearance.

28) Piebalds (pb₁pb₁). DEMEREC (1128). The plants have irregular white or yellowish spots in the seedling stage which may or may not disappear with age. Four genes are concerned in this character, two of which (pb₁ and pb₂) are simple Mendelian recessives; the other two (pb₃ and pb₄) are duplicate genes.

SIZE CHARACTERS

A number of quantitative characters have been genetically investigated in corn plants. They are: diameter, breadth and weight of grains,

number of rows on the ear, length and diameter of ears, height of plants, number and length of internodes, number of days to pollination, number of days from pollination to silking, size of aleurone cells and other characters. Papers concerned are many, of which we may mention CORRENS (10), LOCK (63), EAST (130), EMERSON (132), EAST & HAYES (165), HAYES (238), EMERSON & EAST (283), MANDEKIĆ (566, 1054) and KEMPTON (1174). However, none of these characters are satisfactorily analyzed. Generally speaking, the F_1 condition is intermediate between the parents, and complex segregation is obtained in F_2 . Intermediates, as well as extremes, which breed true, appear in later generations. Apparently there are many genes affecting these size characters, but according to KEMPTON, the correlations between them are low or negligible.

SAX (1209) found a correlation between color of grain and size of ears. A variety with very small ears and white grains was crossed with a variety with comparatively large ears and yellow grains. In F_2 a 3:1 ratio of yellow and white grains was obtained, in which the yellow class was distinctly larger than the white, and the homozygous yellow segregates were almost as large as the heterozygous yellow.

PHYSIOLOGICAL CHARACTERS

Resistance to Disease. According to JONES (552), susceptibility to corn smut (*Ustilago zeae*) and an unidentified leaf blight behaves as a recessive character, for only 2.28 per cent of F_1 plants were affected.

HAYES, STAKEMAN, GRIFFEE & CHRISTENSEN (1150) showed that the F_1 plants between two strains resistant to smut were more resistant than either parent, while F_1 crosses between resistant and susceptible strains produced an intermediate type.

Recently, IMMER & CHRISTENSEN (1274) made crosses between low, medium, and high smut strains. The F_1 tended to be intermediate and the F_2 closely resembled the F_1 . They concluded, therefore, that there is no definite dominance of resistibility or susceptibility.

Deficiency in Carbohydrate Metabolism. EYSTER (1137) found a yellow seedling which was unable to utilize the carbohydrates in the endosperm, and dies within a week after emergence under field conditions. This type is inherited as a simple recessive to normal. The gene was symbolized as glu.¹⁾

1) The original symbol of this gene was gl. But this symbol had been used for glossy leaf by LINDSTROM (1052). Hence we may substitute glu for it.

'*Primitive Sporophyte*'. EYSTER (1139) found grains with embryos that do not become dormant in the seed stage, but continue to grow as long as there is enough moisture in the endosperm and cob to permit it. The endosperm is non-defective. This growth habit was called 'primitive sporophyte', because of its resemblance to the sporophytes of more primitive plants. This character is also recessive to the normal condition, and two independent genes, $\underline{pm}_1$ and $\underline{pm}_2$ are concerned in it. The cross $\underline{Pm}_1\underline{Pm}_1\underline{pm}_2\underline{pm}_2 \times \underline{pm}_1\underline{pm}_1\underline{Pm}_2\underline{Pm}_2$ gave normal F_1 and in F_2 a ratio of 9:7.

Proterogyny. Most maize plants are proterandrous, the pollen being shed from 3 to 5 days before the first silks appear. KEMPTON (1176), however, found proterogyny in a variety of maize from Spain, in which the pollen is first shed 2 or 3 days after the first silks emerge. In crosses between these two types, F_1 was proterandrous. Segregation occurred in F_2 , but proterogynous plants were too few as a simple Mendelian character.

LIST OF GENES IN *Zea*

- A**: gene for anthocyanin pigmentation in the leaves, sheaths and husks, and for colored aleurone.
- ab**: abortive grains containing no endosperm.
- ad**: adhered leaves and tassel.
- an**: anther ear.
- B**: gene for brown plant color; one of an allelomorphic series **B**, **B^w** and **b**.
- bh**: blotched aleurone.
- bl**: blotched leaf.
- Bn**: brown pericarp.
- br**: brachytic plant.
- by**: dwarf (brevis) plant.
- C**: gene for colored aleurone, complementary to **A** and **R**.
- co**: coherent branches of tassel.
- cr**: crinkly leaf.
- d**: true dwarf plant.

- df**: defective endosperm.
dl: dead leaf-margin.
dt: dotted leaf.
f: fine-striped leaf.
fi: fine-streaked leaf.
Fl: flinty endosperm.
fs: fasciated ear.
g: golden leaf.
gl: glossy leaf. *
glu: glucostacty.
gs: green-striped leaf.
I: inhibitor of aleurone color.
ij: iojap-striped leaf.
In: gene for dilution of aleurone colors ; **in** results in dark colors.
j: japonica-striped leaf.
l (**l₁** & **l₂**): yellow seedlings.
lg: liguleless and non-auriculate condition.
li: lineate leaf.
m (**m₁** & **m₂**): yellow-white leaf.
mg: minuate germ.
ms: male-sterile.
na: nana plant.
nk: cob and tassel almost free from spikelets.
P: gene for pericarp and cob color ; an allelomorphic series **P^{pr}**, **P^{wt}**, **P^{ow}**, etc.
pb (**pb₁**-**pb₄**): piebalds.
Pl: gene for purple plant color.
pg (**pg₁**-**pg₅**): pale green leaf (type 1-5).
pk: polkadot leaf.
pm (**pm₁** & **pm₂**): primitive sporophyte.
Pr: gene producing purple aleurone in presence of **A**, **C**, **R** and **i**.
R: gene producing red aleurone in presence of **A**, **C** and **i**; and also one of an allelomorphic series affecting plant colors and pericarp : **R^r**, **R^g**, **r^r**, **r^g**, **r^{ch}**, etc.

- ra : ramosa ear.
rs : spotted aleurone.
sc : scarred endosperm.
sh : shrunken endosperm.
sk : silkless ear.
Sm: gene for silk color ; sm produces salmon silks in presence of **A** and **P**.
su : sugary endosperm.
te : tassel ear.
Tp: teopod ear.
ts : tassel seed.
Tu: tunicate ear.
tw (tw₁-tw₃) : twisted seedlings.
v (v₁-v₆) : virescent seedlings.
w (w₁-w₁₀) : white seedlings.
Wh: inhibitor of **Y**- and **Yp**-effects.
wl : white-base leaf.
ws : white sheath.
wx: waxy endosperm.
Y : yellow endosperm.
Yp: pale yellow endosperm.
xn (xn₁ & xn₂) : xantha leaf.
ys : yellow-striped leaf.
z & zg : zigzag culm.
zb₁: zebra-striped mature plant.
zb₂ (or ze₁-ze₄) : zebra-striped seedlings.

LINKAGE RELATIONS¹⁾

Extensive works have been done by a number of experimentors on the genic analysis in *Zea Mays*. Up to the present, eight groups of linked genes have been established with certainty. These, according to the genic notation mentioned above, are :

1) The haploid chromosome number in *Zea Mays* is generally 10. (Vide TISCHLER, *loc. cit.*)

- 1) $\underline{\text{C-Wx}}$; 25 %.¹⁾ COLLINS & KEMPTON (164), BREGGER (528),
KEMPTON (640), STADLER (1306).

$\underline{\text{Sh-C}}$; 3.4 %	}	HUTCHISON (795, 913).
$\underline{\text{Sh-I}}$; 3.6 %		
$\underline{\text{Sh-Wx}}$; 21.8 %		
$\underline{\text{V}_1\text{-C}}$; 30 %	}	DEMEREK (1126).
$\underline{\text{Wx-V}_1}$; 7 %		

The order of these genes : $\underline{\text{V}_1\text{-Wx-Sh-C-I}}$.

- 2) $\underline{\text{L}_1\text{-R}}$; almost no crossover. LINDSTROM (501, 561, 810).
 $\underline{\text{W}_2\text{-R}}$; 15.4%. LINDSTROM (1189).²⁾
 $\underline{\text{W}_2\text{-Df}}$; no crossover. LINDSTROM (1051).
 $\underline{\text{L}_2\text{-R}}$; 35 %. LINDSTROM (1285).

The order of these genes : $\underline{\text{L}_1\text{-R-W}_2\text{-Df-L}_2}$.

In addition to these, a partial linkage has been found between **R** and **G** (20% ; LINDSTROM, 501, 561, 810); **G** and **L₁** (LINDSTROM, 501); **R** and **S** (KEMPTON, 641); **R** and **Li** (HUTCHISON, 795); **D** and **L₁** (41.7%?; LINDSTROM, 718); and **R** and **Pg₁** (23.3 % ; BRUNSON, 1115).

- 3) $\underline{\text{Su-Tu}}$; 28.6 %. JONES & GALLASTEGUI (635). EYSTER (782, 892). ETHERIDGE, EYSTER & STADLER (891).
 $\underline{\text{Wl-Su}}$; 25 %(?). STROMAN (1217).

In addition to these, WENTZ (1326) found a close linkage between a type of defective endosperm, described as 'sweet defective' by LINDSTROM (1051) and sugary endosperm, with a crossover percentage of 3.2.

- 4) $\underline{\text{B-Lg}}$; 30.32 % }
 $\underline{\text{B-Te}}$; 20.8 % } EMERSON (689).
 $\underline{\text{Te-Lg}}$; 45.8 % }
 $\underline{\text{V}_4\text{-Lg}}$; 43 % }
 $\underline{\text{B-V}_4}$; 17 % } DEMEREK (1126).

1) The figure gives the crossover percentage between the genes. These figures, however, are not very definitive, but fluctuate somewhat considerably. For instance, STADLER (1306) measured crossing over in three different strains, based on back-crosses involving **C** and **Wx**. One was found to have 17.90 ± 0.15 , another 22.62 ± 0.31 , and still others 25.85 ± 0.32 .

2) STROMAN (1217) reports a linkage involving **W₂** and an uncertain gene pair causing red- and non-red-stem seedlings (**rg**?), with 17 % of crossing over.

The order of these genes : $\underline{\text{Te}}-\underline{\text{V}_1}-\underline{\text{B}}-\underline{\text{Lg}}$.

JONES (1276) added $\underline{\text{Sk}}$ to this group, $\underline{\text{B}}$ and $\underline{\text{Sk}}$ giving a crossover percentage of 10.5.

5) $\underline{\text{Y}}-\underline{\text{Pl}}$; 29.7 %. EMERSON (778), ANDERSON (753).

$\underline{\text{Sm}}-\underline{\text{Y}}$; 36.8 %
 $\underline{\text{Pl}}-\underline{\text{Sm}}$; 10 % } ANDERSON (753).

$\underline{\text{Y}}-\underline{\text{W}_1}$; 35-45 %. STROMAN (1217), LINDSTROM (1189).

$\underline{\text{W}_1}-\underline{\text{Pl}}$; 25 %. STROMAN (1217).

The order of these genes : $\underline{\text{W}_1}-\underline{\text{Sm}}-\underline{\text{Pl}}-\underline{\text{Y}}$.

In addition to these, a close linkage has been found between $\underline{\text{Pm}}$ and $\underline{\text{W}_1}$ (EYSTER, 1139); and also between $\underline{\text{Y}}$ and $\underline{\text{Fi}}$ (ANDERSON, 1102). DEMEREC (1000) established also a series $\underline{\text{W}_5}-\underline{\text{Y}}-\underline{\text{W}_6}$, with a crossover percentage of 36.9 between $\underline{\text{W}_5}$ and $\underline{\text{W}_6}$ and about 25 in each region. STROMAN (1217) added still other genes to this group, $\underline{\text{M}_1}$ and $\underline{\text{M}_2}$; $\underline{\text{M}_1}$ and $\underline{\text{Y}}$ gave about 25 %, and $\underline{\text{M}_1}$ and $\underline{\text{M}_2}$ about 33 % crossing over.

6) $\underline{\text{Br}}-\underline{\text{P}}$; 35 %. KEMPTON (713, 802, 923).

$\underline{\text{P}}-\underline{\text{Ts}}$; no crossover. EMERSON (778).

7) $\underline{\text{A}}-\underline{\text{V}_1}$; 45 %. STROMAN (1217).

The gene $\underline{\text{V}_1}$ belonging to this group, is not identical with that of the first linkage group.

8) $\underline{\text{Bn}}-\underline{\text{Gl}}$; 18.7-29.4 %
 $\underline{\text{Bn}}-\underline{\text{V}_5}$; 24.9 %
 $\underline{\text{Gl}}-\underline{\text{V}_5}$; 6.2 %
 $\underline{\text{Bn}}-\underline{\text{Ra}}$; 38.2 % } KVANKAN (1180).

The relative order of these genes : $\underline{\text{Ra}}-\underline{\text{Bn}}-\underline{\text{Gl}}-\underline{\text{V}_5}$ or $\underline{\text{Bn}}-\underline{\text{Gl}}-\underline{\text{V}_5}-\underline{\text{Ra}}$.

DEMEREC (1247) added another gene $\underline{\text{Pg}_3}$ to this group, $\underline{\text{Pg}_3}$ and $\underline{\text{Bn}}$ giving 4.5 % crossing over.

Other genes which have been fairly well tested against others, such as $\underline{\text{Gs}}$, $\underline{\text{J}}$ and $\underline{\text{Pg}_4}$, may still produce other groups. According to EYSTER (893), $\underline{\text{Zg}}$ and $\underline{\text{Gs}}$ are completely or very closely linked. As to the gene $\underline{\text{D}}$, DEMEREC (1126) found that it is possibly linked with $\underline{\text{V}_4}$, and in a later paper (1247) he also gave evidence indicating that $\underline{\text{D}}$ is partially linked with $\underline{\text{Pg}_2}$, with 32 % crossing over. These genes therefore may be included in the fourth linkage group.

Part II

Bibliography on Genic Analysis in Plants

With brief comments

This bibliography is compiled as an attempt to give a comprehensive list of works on genic analysis in plants, which have appeared since the rediscovery of Mendel's law. The works on the list are chronologically arranged, so that it may serve as material for a history of development of this new branch of science. Works published in one and the same year, however, are arranged in the alphabetical order of the author's names. The list comprises 1335 publications, which appeared during the years 1900-1925, to which six works of later dates, having closer bearing on other works, are added, and are numbered consecutively. The list, however, does not pretend to be complete.

The title of each work is accompanied by a short comment, which may serve as an indication of the contents of the work.

It may be also added that some works dealing with crossing experiments, have been included, although not directly concerned with genic analysis. Especially on these some detailed comments are made, as no reference has been made to them in Part I.

1900.

- (1) CORRENS, C., G. Mendel's Regel über das Verhalten der Nachkommenschaft der Rassenbastarde. *Ber. Deut. Bot. Ges.*, 18: 158-168, '00. Reprinted in No. (1122).

On the inheritance of cotyledon color in *Pisum*, confirming the Mendel's results.

- (2) CORRENS, C., Gregor Mendel's "Versuche über Pflanzen-Hybriden" und die Bestätigung ihrer Ergebnisse durch die neuesten Untersuchungen. *Bot. Ztg.*, 58: 229-235, '00. Reprinted in No. (1122).

Including remarks on crossing experiments with *Epilobium angustifolium*.

- (3) CORRENS, C., Ueber Levkojenbastarde. Zur Kenntnis der Grenzen der Mendel'schen Regeln. *Bot. Cbl.*, 84: 97-113, '00. Reprinted in No. (1122).

Recording chiefly crosses between *Matthiola incana* and *M. glabra*, as to the inheritance of several characters, flower color, seed coat color, aleurone color, hoariness, seed form, growth habit, floral construction and flowering time.

- (4) HILDEBRAND, F., Ueber Bastardierungsexperimente zwischen einigen *Hepatica*-Arten. *Bot. Obl.*, 84: 65-73, '00.

Observations on F_1 plants in crosses between three species of *Hepatica* (*Anemone*), as to flower color, leaf form and other characters.

- (5) TSCHERMAK, E. v., Ueber künstliche Kreuzung bei *Pisum sativum*. *Zts. Landw. Versuchsw. Oesterr.*, 1900: 1-91, '00.

On the inheritance of seed form, cotyledon color (up to F_2), height of plant and form of pods (F_1) in peas. The results are briefly summarized under the same title in *Biol. Centralbl.* 20: 593-595, '00 and also in *Ber. Deutsch. Bot. Ges.* 18: 232-239, '00.

- (6) VRIES, H. DE, Hybridising of monstrosities. *Jour. Roy. Hort. Soc.*, 24: 69-75, '00.

Recording cross-experiments between *Lychnis vespertiana glabra* and *L. diurna*, with the object of obtaining the glabrous form of the latter.

- (7) VRIES, H. DE, Sur la fécondation hybride de l'endosperme chez le maïs. *Rev. Gén. Bot.*, 12: 129-137, '00.

Recording endosperm xenia in the cross between sugary and starchy corns.

- (8) VRIES, H. DE, Das Spaltungsgesetz der Bastarde. Vorläufige Mittheilung. *Ber. Deut. Bot. Ges.*, 18: 83-90, '00.

Giving cases of Mendelian inheritance of various plants, such as *Papaver somniferum-nanum*, *Antirrhinum majus-album*, *Agrostemma Githagonicaeensis*, *Hyoscyamus niger-pallidus*, *Chelidonium majus-lacinia-tum*, *Chrysanthemum Roxburghi-album*, etc.

- (9) VRIES, H. DE, Sur la loi de disjonction des hybrides. *Compt. Rend. Acad. Sci.*, 130: 845-847, '00.

Containing similar account as in the preceeding paper.

1901.

- (10) CORRENS, C., Bastarde zwischen Maisrassen, mit besonderer Berücksichtigung der Xenien. *Bibl. Bot.* 53: 1-161, '01. Reprinted in No. (1122).

Giving a full account of inheritance of several seed characters in maize, shape, size, endosperm texture, aleurone layer- and pericarp-color, etc.

- (11) TSCHERMAK, E. v., Ueber Züchtung neuer Getreiderassen mittelst künstlicher Kreuzung. *Zts. Landw. Versuchsw. Oesterr.*, 1901: 1029-1060, '01.

Recording various cases of Mendelian inheritance in wheat, barley, oat and rye.

- (12) TSCHERMAK, E. v., Weitere Beiträge über Verschiedenwerthigkeit der Merkmale bei Kreuzung von Erbsen und Bohnen. Vorläufige Mittheilung. *Ber. Deut. Bot. Ges.*, 19: 35-51, '01.

On the inheritance of cotyledon characters in peas (chiefly F_2 and F_3), and of certain seed coat and vegetative characters, including seed- and flower-color, height of stem, form of pods, etc., in peas and beans (F_1 and F_2). Also some observations on a cross, *Phaseolus vulgaris* $\times$ *Ph. multiflorus*.

- (13) VRIES, H. DE, *Die Mutationstheorie*. 2 vols. Leipzig. '01-'03.

A well known work to which several references have been made in Part. I.

1902.

- (14) BATESON, W., Note on the resolution of compound characters by cross-breeding. *Proc. Phil. Soc.*, 12: 50-54, '02-'04.

Giving a new genic interpretation of the results on flower-color inheritance in *Antirrhinum* recorded by DE VRIES (No. (13). II, p. 196).

- (15) BATESON, W., AND E. R. SAUNDERS, Experimental studies in the physiology of heredity. *Rept. Evol. Com. Roy. Soc.*, Rept. I, 160 pages. '02.

On the inheritance of flower-color and hoariness in *Lychnis*, color in flowers, fruits and stem of *Atropa* and *Datura*, fruit surface character in *Datura*, color in flowers and seeds and hoariness in *Matthiola*.

- (16) CORRENS, C., Scheinbare Ausnahmen von der Mendelschen Spaltungsregel für Bastarde. *Ber. Deut. Bot. Ges.*, 20: 159-171, '02. Reprinted in No. (1122).

On the inheritance of endosperm texture in crosses between a black sugar maize and a white pop maize. A marked deficiency of the recessive (dextrin) character in F_2 is observed.

- (17) CORRENS, C., Ueber Bastardierungsversuche mit *Mirabilis*-Sippen. *Ber. Deut. Bot. Ges.*, 20: 594-608, '02. Reprinted in No. (1122).

Recording crosses between varieties of *M. Jalapa* and also *M. Jalapa* $\times$ *M. longiflora* as to inheritance of flower color, height of plant and chlorophyll characters.

- (18) HURST, C. C., Mendel's law applied to orchid hybrids. *Jour. Roy. Hort. Soc.*, 26: 688-695, '02.

Several cases of Mendelian distribution of color in orchids.

- (19) MACOUN, W. T., Notes on the breeding of peas and beans. *Proc. Internat. Conf. on Plant Breed. and Hybridizat. Hort. Soc.*: 197-198, '02.

- (20) SAUNDERS, C. E., Note on some variations in the second generation of *Berberis* hybrids. *Proc. Internat. Conf. on Plant Breed. and Hybridizat. Hort. Soc.*: 167-168, '02.

On the inheritance of certain characters in the cross, *B. Thunbergii* $\times$ *B. vulgaris purpurea*.

- (21) SPILLMAN, W. J., Quantitative studies on the transmission of parental characters to hybrid offspring. *U. S. Dept. Agr. Exp. Sta. Bull.*, 115: 88-98, '02.

Observations on F_1 and F_2 of *Triticum compactum* $\times$ *T. vulgare*, with respect to ear density, awning, color of glumes and pubescence on glumes. Compare comment to No. (33).

- (22) TSCHERMAK, E. v., Über Korrelation zwischen vegetativen und sexualen Merkmalen an Erbsenmischlingen. *Ber. Deut. Bot. Ges.*, 20: 17-21, '02.

On the relationship of flower color to seed surface character in *Pisum* crosses.

- (23) TSCHERMAK, E. v., Der gegenwärtige Stand der Mendel'schen Lehre und die Arbeiten von W. BATESON. *Zts. Landw. Versuchsw. Oesterr.*, pp 43, '02.

Review of BATESON & SAUNDER'S work (No. (15)), together with new data from the author's observations on flower color in *Matthiola*. Production of red from white and yellow is recorded.

- (24) TSCHERMAK, E. v., Ueber die gesetzmässige Gestaltungsweise der Mischlinge. Fortgesetzte Studien an Erbsen und Bohnen. *Zts. Landw. Versuchsw. Oesterr.*, pp 81, '02.

Concerning further experiments with *Pisum* and *Phaseolus*. Recording F_2 segregation of two characters of peas: breadth of pods and number of flower in peduncle and coupling of *Pisum arvense* characteristics (color in flowers, leaf-axils and seeds) in crosses with *P. sativum*. Also on the inheritance of several characters in *Phaseolus vulgaris* $\times$ *Ph. multiflorus*.

- (25) VRIES, H. DE, On artificial atavism. *Proc. Internat. Conf. on Plant Breed. and Hybridizat. Hort. Soc.*: 17-24, '02.

An account of some cross-breeding in *Antirrhinum* as to the color of flowers.

1903.

- (26) BIFFEN, R. H., Wheat breeding. *Proc. Phil. Soc.*, 12: 279-283, '03.

A preliminary account of a long series of experiments as to several characters involving grain, glume, ear, stem, leaves and resistance to rust.

- (27) CANNON, W. A., Studies in plant hybrids: The spermatogenesis of hybrid peas. *Bull. Torr. Bot. Club.*, 30: 519-543, '03.

On the inheritance of cotyledon color and height of plant in peas.

- (28) CORRENS, C., Ueber dominierenden Merkmale der Bastarde. *Ber. Deut. Bot. Ges.*, 21: 133-147, '03. Reprinted in No. (1122).

On the inheritance of carotin content in flowers of *Argemone*, chlorophyll content in leaves of *Mirabilis*, anthocyanin content in flowers of *Hyoscyamus* and *Melandrium*.

- (29) CORRENS, C., Weitere Beiträge zur Kenntniss der dominierenden Merkmale und der Mosaikbildung der Bastarde. *Ber. Deut. Bot. Ges.*, 21: 195-201, '03. Reprinted in No. (1122).

Giving examples of complete dominance (vegetative duration in *Hyoscyamus* and sex in *Bryonia*), incomplete dominance (color and shape of the root of radish, and flower color in *Phyteuma*) and dominant white (flower color in *Polemonium*).

- (30) GREGORY, R. P., The seed character of *Pisum sativum*. *New Phytologist.*, 2: 226, '03.

On a microscopic examination of the difference between round and wrinkled peas.

- (31) HURST, C. C., Mendel's principles applied to orchid hybrids. *Jour. Roy. Hort. Soc.*, 27: 614-624, '03. Reprinted in No. (1268).

On the inheritance of the ground-color and color-markings on the dorsal sepal of the flower in *Paphiopedilum*.

- (32) HURST, C. C., Recent experiments in the hybridisation of orchids. *Gard. Chron.*, 2: 226-227, '03. Reprinted in No. (1268).

Containing similar results as in No. (32) also recording complete dominance of *Epidendrum* characters over *Sophranitis* characters, and monolepsis in *Zygopetalum* crosses.

- (33) HURST, C. C., Mendel's principles applied to wheat hybrids. *Jour. Roy. Hort. Soc.*, 27: 876-894, '03. Reprinted in No. (1268).

Giving a detailed analysis of the results from crosses of *Triticum vulgare* and *T. compactum* carried out by W.J. SPILLMAN who was in ignorance of Mendel's work. Compare comment to No. (21).

- (34) KAIZER, H., Ueber künstliche Kreuzungen von Victoria- und Prinzess Royal-Erbesen. *Deutsch. Landw. Presse.*, 30: 213, '03.

On the inheritance of height of stem and seed surface character in peas.

1904.

- (35) BIDGOOD, J., Albinism, with special reference to shirley poppies. *Jour. Roy. Hort. Soc.*, 28: 477-482, '04.

Containing general discussion on albinism, including remarks on color inheritance in *Cypripedium*.

- (36) BRAINERD, E., Hybridism in the genus *Viola* II. *Rhodora*, 6: 213-223, '04. Rev. in *Zts. Ind. Abst. u. Vererbgs.*, 9: 352.

- (37) CORRENS, C., Experimentelle Untersuchungen über die Gynodioecie. *Ber. Deut. Bot. Ges.*, 22: 506-517, '04. Reprinted in No. (1122).

On the inheritance on sex in gynodioecious plants, *Satureja hortensis* and *Silene inflata*.

- (38) CORRENS, C., Ein typisch spaltender Bastard zwischen einer einjährigen und einer zweijährigen Sippe des *Hyoscyamus niger*. *Ber. Deut. Bot. Ges.*, 22: 517-524, '04. Reprinted in No. (1122).

On the inheritance of flower color in *Hyoscyamus* and of leaf character in *Urtica*.

- (39) EMERSON, R. A., Heredity in bean hybrids. *Ann. Rept. Nebraska Agr. Exp. Sta.*, 17: 33-68, '04.

On the production of anthocyanin in testa of F_1 from two varieties without pigment. Also recording crossing experiments as to pod color, flower color, pod texture, stature, etc.

- (40) HURST, C. C., Mendel's discoveries in heredity. *Trans. Leicester Lit. & Phil. Soc.*, 8: 121-134, '04. Reprinted in No. (1268).

Giving a brief list of some of the Mendelian characters found in the author's experiments with peas, orchids, berberis, sweet peas and primula.

- (41) HURST, C. C., Experiments in the heredity of peas. *Jour. Roy. Hort. Soc.*, 28: 483-494, '04. Reprinted in No. (1268).

An account of an experimental examination of Mendel's laws, dealing with seed shape and cotyledon color in *Pisum*.

- (42) LOCK, R. H., Studies in plant breeding in the tropics I. Introductory: The work of Mendel and an account of recent progress along the same lines, with some new illustrations. *Ann. Roy. Bot. Gard.*, 2: 299-356, '04.

Preliminary notes on some Mendelian inheritance in peas (seed surface character, flower color, pod texture, seed coat color, seed shape and flowering time) and maize (aleurone layer color).

- (43) TSCHERMAK, E. v., Die Theorie der Kryptomerie und des Kryptohybridismus. I. Mittheilung. Über die Existenz kryptomerer Pflanzenformen. *Beih. Bot. Cbl.*, 16: 11-35, '04.

Describing cases of 'Kryptomerie' in *Pisum*, *Phaseolus*, *Matthiola* and *Hordeum*.

- (44) TSCHERMAK, E. v., Weitere Kreuzungsstudien an Erbsen, Levkojen und Bohnen. *Zts. Landw. Versuchsw. Oesterr.*, 7, pp 106, '04.

On the inheritance of several color characters, and flowering time in peas; flower color in *Matthiola*; color characters and stature in beans.

Also further observations on the cross of *Phaseolus vulgaris* × *Ph. multiflorus*.

- (45) WILSON, J. H., Variation in oat hybrids. *Nature*, 69: 413, '04.

A short account of inheritance of grain color.

1905.

- (46) BATESON, W., AND R. P. GREGORY, On the inheritance of heterostylism in *Primula*. *Proc. Roy. Soc.*, 76: 581-586, '05.

Recording experiments with *P. sinensis* and *P. acaulis*. Relationship of heterostylism to eye character is also discussed.

- (47) BATESON, W., E. R. SAUNDERS, R. C. PUNNETT, AND C. C. HURST, Experimental studies in the physiology of heredity. *Rept. Evol. Com. Roy. Soc.*, Rept. II, pp 154, '05.

Recording experiments with *Datura*, *Matthiola*, *Salvia*, *Ranunculus* (reported by SAUNDERS), *Pisum* (by BATESON & KILLBY) and *Lathyrus* (by BATESON, SAUNDERS, & PUNNETT). Characters observed are: fruit surface characters in *Datura*; hoariness, flower color doubling of flowers, and gland characters in *Matthiola*; flower color in *Salvia*; fruit surface characters in *Ranunculus*; stature, cotyledon color, seed shape, testa color, pod shape, type of inflorescence, flower and axil color in *Pisum*; pollen shape, flower and axil color, 'Cupid' type of growth, and 'Snapdragon' shape of flower in *Lathyrus*.

- (48) BIFFEN, R. H., Mendel's laws of inheritance and wheat breeding. *Jour. Agr. Sci.*, 1: 4-48, '05.

On the inheritance of several characters in a series of wheat crosses. Characters studied are: awning, pubescence on the glume, glume color, grain color, keeling of the glume, density of spike, solidity of the straw, pubescence on the foliage, shape of the leaf, time of ripening, length of grains and glumes, endosperm texture, immunity to yellow rust and texture of the glume.

- (49) BIFFEN, R. H., Inheritance of sterility in the barley. *Jour. Agr. Sci.*, 1: 250-257, '05.

Observations on the inheritance of several types of barley spike.

- (50) CORRENS, C., Einige Bastardierungsversuche mit anomalen Sippen und ihre allgemeinen Ergebnisse. *Jahrb. Wiss. Bot.*, 41: 458-484, '05. Reprinted in No. (1122).

On the inheritance of calycanthemy in *Campanula medium* and *Mimulus tianinus*.

- (51) CORRENS, C., Zur Kenntnis der scheinbar neuen Merkmale der Bastarde. *Ber. Deut. Bot. Ges.*, 23: 70-85, '05. Reprinted in No. (1122).

Further observations on inheritance (chiefly F_2 and F_3) of flower color in *Mirabilis Jalapa*.

- (52) CORRENS, C., Weitere Untersuchungen über die Gynodiöcie. *Ber. Deut. Bot. Ges.*, 23: 452-463, '05. Reprinted in No. (1122).

Recording further experiments on inheritance of sex in gynodioecious plants, *Satureja hortensis* and *Silene inflata*, and also on an androdioecious plant, *Geum* sp.

- (53) GREGORY, R. P., Abortive development of the pollen in certain sweet peas (*Lathyrus odoratus*). *Proc. Cambridge Phil. Soc.*, 13: 148-157, '05.

On the inheritance of anther sterility in sweet pea.

- (54) HALSTED, B. D., Reports of the botanist. *New Jersey Agr. Exp. Sta. Rept.* 1905: 423-527, '05.

Recording several cases of Mendelian inheritance in the garden tomato.

- (55) LOCK, R. H., Studies in plant breeding in the tropics II. Experiments with peas. *Ann. Roy. Bot. Gard.*, 2: 357-414, '05.

On the experiments with *Pisum*, dealing with cotyledon and testa color, pod texture, stature, etc.

- (56) VRIES, H. DE, *Species and varieties. Their origin by mutation.* Chicago and London, '05.

Several references are made in Part I.

1906.

- (57) BATESON, W., E. R. SAUNDERS, AND R. C. PUNNETT, Experimental studies in the physiology of heredity. *Rept. Evol. Com. Roy. Soc.*, Rept. III, pp 53, '06.

Recording experiments on inheritance of color in flowers and axils of sweet pea (reported by BATESON, SAUNDERS & PUNNETT), and on flower color and hoariness in stocks (by SAUNDERS).

- (58) BATESON, W., E. R. SAUNDERS, AND R. C. PUNNETT, Further experiments on inheritance in sweet peas and stocks. Preliminary account. *Proc. Roy. Soc.*, 77: 236-238, '06.

Giving a genic interpretation of 'reversions' from two white varieties of *Lathyrus*, and from white glabrous × cream glabrous in *Matthiola*. Coupling between pollen shape and flower color in *Lathyrus* is also noted.

- (59) BIFFEN, R. H., Experiments on the hybridisation of barleys. *Proc. Cambridge Phil. Soc.*, 13: 304-308, '06.

Giving a list of several allelomorphic pairs involving grain, glume, and ear characters of barleys.

- (60) BRAINERD, E., Hybridism in the genus *Viola* III. *Rhodora*, 8: 49-60, '06. Rev. in *Zts. Ind. Abst. u. Vererbgs.*, 9: 352.

- (61) CORRENS, C., Die Vererbung der Geschlechtsformen bei den

gynodiöcischen Pflanzen. *Ber. Deut. Bot. Ges.*, 24: 459-474, '06. Reprinted in No. (1122).

Recording further observations on sex inheritance in *Satureja hortensis* and *Silene inflata*, together with new experiments with *Silene dichotoma* and *Plantago lanceolata*.

(62) CORRENS, C., Ein Vererbungsversuch mit *Dimorphotheca pluvialis*. *Ber. Deut. Bot. Ges.*, 25: 162-173, '06. Reprinted in No. (1122).

On the inheritance of sex in this gynomonoecious plant.

(63) LOCK, R. H., Studies in plant breeding in the tropics III. Experiments with maize (*Zea Mays* L.). *Ann. Roy. Bot. Gard.*, 3: 95-184, '06.

On the inheritance of endosperm texture (starchy vs. sugary), its color (yellow vs. white), and aleurone layer color (blue vs. white) in maize. With appendices dealing with experiments carried out upon *Phaseolus vulgaris* (color in pods and testa) and *Canavalia ensiformis* (habit of growth, color in flowers and testa).

(64) RAUNKIAER, C., Sur la transmission par hérédité dans les espèces hétéromorphes. *Acad. Roy. Soc. et Lettr. Danemark, Bull. de l'année*, 1: 31-39, '06. Rev. in *Bot. Jahresber.*, 1906: 743.

Concerning experiments on heterostylism in *Primula officinaris* and on sex in gynodioecious plants, *Thymus vulgaris* and *Knautia arvensis*.

(65) TSCHERMAK, E. V., Über Züchtung neuer Getreiderassen mittelst künstlicher Kreuzung. II. Mitteilung. Kreuzungsstudien am Roggen. *Zts. Landw. Versuchsw. Oesterr.*, 1906, pp 45, '06.

Account of formation of endosperm xenia and inheritance of seed color, type of spike, seed form and winter-hardiness in rye. Also observations on crosses with cultivated and wild forms: *Secale cereale* × *S. montanum*, *Aegilops ovata* × *S. montanum*, *Hordeum tetrastichum* × *H. spontaneum*.

1907.

(66) BALLS, W. L., Notes on Mendelian heredity in cotton. *Jour. Agr. Sci.*, 2: 216, '07.

Preliminary account. See No. (86).

(67) BAUR, E., Untersuchungen über die Erbliehkeitsverhältnisse einer nur in Bastardform lebensfähigen Sippe van *Antirrhinum majus*. *Ber. Deut. Bot. Ges.*, 25: 442-454, '07.

On the inheritance of the 'aurea' type in *Antirrhinum*.

(68) BIFFEN, R. H., Experiments on the breeding of wheats for

English conditions. *Rept. Conf. Genetics, Roy. Hort. Soc.*, pp. 373-377, '07.

On the Mendelian principles applied to wheat breeding, chiefly concerning resistance to attack of yellow rust.

- (69) BIFFEN, R. H., Studies in the inheritance of disease resistance. *Jour. Agr. Sci.*, 2: 109-128, '07.

On the inheritance of mode of reaction to several rusts and mildews in wheat and barley crosses.

- (70) BIFFEN, R. H., The hybridisation of barleys. *Jour. Agr. Sci.*, 2: 183-206, '07.

Characters observed are: type of spike, hoodedness, paleae color, grain color, breadth of glume, density of spike, adherence of paleae, brittleness of rachis, etc.

- (71) BRAINERD, E., Mendel's law of dominance in *Viola Rhodora*, 9: 211-216, '07. Rev. in *Zts. Ind. Abst. u. Vererbgsst.*, 9: 352.

- (72) CRAIG, A. G., Mendel's law applied to tomato breeding. *Proc. Soc. Hort. Sci.*, 5: 24-27, '07.

On the inheritance of dwarfishness, fruit color, and productiveness.

- (73) FLETCHER, F., Mendelian heredity in cotton. *Jour. Agr. Sci.*, 2: 281-282, '07.

Brief account of inheritance of anthocyanin in flowers, length of the lint, 'fuzziness' covering seeds, etc.

- (74) GREGORY, R. P., On the inheritance of certain characters in *Primula sinensis*. *Rept. Brit. Assoc.*, pp. 691-693, '07.

Including remarks on inheritance of heterostylism, the presence or absence of a large yellow 'eye', form of the leaf, and color in flower and stem.

- (75) HEDRICK, U. P., AND N. O. BOOTH, Mendelian characters in tomatoes. *Proc. Soc. Hort. Sci.*, 5: 19-24, '07.

On the inheritance of dwarfishness, color and shape of fruit.

- (76) HURST, C. C., Mendelian characters in plants and animals. *Rept. Conf. Genetics, Roy. Hort. Soc.*, pp. 114-128, '07. Reprinted in No. (1268).

Review of the author's experiments with peas (cotyledon color, seed shape, dwarfishness), sweet peas (flower color, dwarfishness, pollen shape), poppies (flower color), snapdragons (flower color), tomatoes (flesh- and skin-color), primulas (stem color, form of the leaf, heterostylism) and orchids (flower color).

- (77) JENSEN, H., Tobacco experiments. *Jaarb. Dept. Landb. Nederland Indie*: 199-217, '07. Rev. in *Exp. Sta. Rec.*, 20: 935.

On the inheritance of quantitative characters in tobacco.

- (78) LOCK, R. H., On the inheritance of certain invisible characters

in peas (*Pisum sativum*). *Proc. Roy. Soc.*, 79: 28-34, '07.

On the genes for seed coat color and pattern.

- (79) NORTON, J. B. Notes on breeding oats. *Ann. Rept. Amer. Breed. Assoc.*, 5: 280-285, '07.

Crosses are made between *Avena nuda* and *A. sativa*.

- (80) SAUNDERS, C. E., The inheritance of awns in wheat. *Rept. Conf. Genetics, Roy. Hort. Soc.*: 370-372, '07.

Some complicated mode of inheritance is shown.

- (81) SAUNDERS, E. R., Certain complications arising in the cross-breeding of stocks. *Rept. Conf. Genetics, Roy. Hort. Soc.*: 143-147, '07.

On the relationship of the genes for hoariness to those for flower color in *Matthiola incana*.

- (82) SHULL, G. H., Elementary species and hybrids of *Bursa*. *Science N.S.*, 25: 590-591, '07.

Remarks on inheritance of shape of the leaf and the capsule in *Capsella*-crosses.

- (83) SHULL, G. H., Some latent characters of a white bean. *Science N.S.*, 25: 828-832, '07.

On the inheritance of color in the seed coat.

- (84) WHELDAL, M., The inheritance of flower-colour in *Antirrhinum majus*. *Proc. Roy. Soc.*, 89: 288-305, '07.

* Giving a suggestion regarding the genes for flower color.

- (85) WILSON, J. H., The hybridisation of cereals. *Jour. Agr. Sci.*, 2: 68-88, '07.

Remarks on some experiments with oats, wheats and barleys.

1908.

- (86) BALLS, W. L., Mendelian studies of Egyptian cotton. *Jour. Agr. Sci.*, 2: 346-379, '08.

Characters studied are: leaf color, flower color, height of stem, habit of growth, time of maturity, weight of seeds, color of fuzz and lint, length of lint, etc.

- (87) BATESON, W., E. R. SAUNDERS, and R. C. PUNNETT, Experimental studies in the physiology of heredity. *Rept. Evol. Com. Roy. Soc.*, Rept. IV, pp 60, '08.

On the inheritance of dwarfishness, branching habit, anther-sterility (in connection with axil color), and the hooded vs. erect vexillum (in connection with flower color) in sweet peas, and double-flowering in stocks.

- (88) BAUR, E., Einige Ergebnisse der experimentellen Vererbungslehre. *Med. Klinik*, 4: 265-292, '08. Cited by ONSLOW in No. (1294).

- On the color-inheritance in *Antirrhinum* and *Mirabilis*.
 (89) BIFFEN, R. H., On the inheritance of strength in wheat. *Jour. Agr. Sci.*, 3: 87-102, '08.

On the inheritance of endosperm texture in connection with nitrogen content.

- (90) COOK, O. F., Reappearance of a primitive character in cotton hybrids. *Bull. Plant Ind., U. S. Dept. Agr. Circ.*, 18, 11 pages, '08.

Dealing with the appearance of some non-Mendelian characters, such as the green fuzz covering seeds and the short lint, from crosses between two cultivated cottons.

- (91) CORRENS, C., Die Rolle der männlichen Keimzellen bei der Geschlechtsbestimmung der gynodiöcischen Pflanzen. *Ber. Deut. Bot. Ges.*, 36: 686-701, '08. Reprinted in No. (1122).

Recording further experiments on sex inheritance in *Satureja hortensis* and *Plantago lanceolata*.

- (92) DARBISHIRE, A. D., On the result of crossing round with wrinkled peas, with especial reference to their starch-grains. *Proc. Roy. Soc.*, 80: 122-135, '08.

Describing the nature of the starch grains in round and wrinkled peas and in the hybrid between them. Also recording experiments on the amount of water absorbed by two kinds of the peas and of the hybrid.

- (93) FYSON, P. F., Some experiments in the hybridising of Indian cottons. *Mem. Dept. Agr. India, Bot. Ser.*, 2: 1-27, '08.

Recording experiments with *Gossypium arboreum* L. var. *neglectum* WATT (= Jari) and *G. herbaceum* L. (= Jowari). Characters studied are: leaf shape, flower color, 'fuzziness', length and fineness of the lint, and habit of bolls.

- (94) LEAKE, H. M., Studies in experimental breeding of the Indian cottons: an introductory note. *Jour. Asiatic Soc.*: 13-30, '08.

On the inheritance of leaf shape in *Gossypium*-crosses.

- (95) LOCK, R. H., The present state of knowledge of heredity in *Pisum*. *Ann. Roy. Bot. Gard.*, 4: 93-111, '08.

Summary of the previous results on the genetics in *Pisum* is given, also recording new results of the author's experiments. Characters observed are: shape and color of the cotyledons; color of the testa, corolla, and leaf axils; color, form and texture of the pod, form of the stem; habit of growth and duration.

- (96) NILSSON-EHLE, H., Einige Ergebnisse von Kreuzungen bei Hafer und Weizen. *Bot. Notis.*, 1908: 257-294, '08. Rev. in *Bot. Jahresber.*, 1908: 391.

On the inheritance of grain color, pubescence on glumes, awning, and other characters in oats and wheats.

- (97) NORTON, J. B., Resistant varieties in the control of plant diseases. *Trans. Peninsula Hort. Soc.*, '08. Cited by JONES in No. (553).

Observations in tomatoes on susceptibility to wilt disease. F_1 plants of susceptible $\times$ resistant are raised.

- (98) ORTON, W. A., The development of farm crops resistant to disease. *U. S. Dept. Agr. Yearbook*: 453-464, '08. Cited by JONES in No. (553).

Observations on F_1 from melons susceptible to wilt disease $\times$ resistant melons.

- (99) PRICE, H. L., and A. W. DRINKARD, Inheritance in tomato hybrids. *Bull. Virginia Agr. Exp. Sta.*, 177: 15-54, '08.

Describing thirteen allelomorphs in tomatoes, involving fruit, foliage, and stature characters.

- (100) SHULL, G. H., A new Mendelian ratio and several types of latency. *Am. Nat.*, 42: 432-451, '08.

On the inheritance of seed coat color and pattern in beans.

- (101) SHULL, G. H., Some new cases of Mendelian inheritance. *Bot. Gaz.*, 45: 103-116, '08.

On the inheritance of flower color in *Helianthus annuus*, *Lychnis dioica* and *Verbascum blattaria*, and of branching habit in *H. annuus*.

- (102) STOK, J. E. VAN DER, Eenige mededeelingen over roode rijst. *Teysmannia*, 65: pp 5, '08. Rev. in *Bot. Cbl.*, 111: 259.

On the inheritance of grain color in rice.

- (103) SUTTON, A. W., Brassica crosses. *Jour. Linn. Soc.*, 38: 337-349, '08.

Crosses are made between various *Brassica* species (*B. oleracea*, *B. rapa*, *B. campestris*, etc.) and their varieties.

1909.

- (104) BACCARINI, P., Una famiglia di ibridi tra varietà di *Solanum Melongena*, L. *Bull. Soc. Bot. Ital.*: 38-47, '08. Rev. in *Bot. Jahresber.*, 1910: 427.

On the inheritance of fruit color in crosses between two varieties of *S. Melongena*.

- (105) BALLS, L., Some cytological aspects of cotton-breeding. *Ann. Rept. Amer. Breed. Assoc.*, 5: 16-28, '09.

Giving suggestion about the genes for the production of fuzziness.

- (106) BATESON, W., *Mendel's Principles of Heredity*. Cambridge, 1909. 3rd Impression with additions 1913.

A general work on genetics. Full references in inheritance in plants are made in Part I.

- (107) BAUR, E., Das Wesen und die Erblchkeitsverhältnisse der 'Varietates albomarginatae hort' von *Pelargonium zonale*. *Zts. Ind. Abst. u. Vererbgs.*, 1: 330-351, '09.

Recording experiments with several varieties having a white leaf-margin, especially in *Pelargonium*.

- (108) BLARINGHEM, L., Sur les hybrides d'orges et la loi de Mendel. *Compt. Rend. Acad. Sci.*, 148: 854-857, '09.

Mention is made that stiff vs. downy hairs on the rachilla and prickly vs. smooth dorsal veins of the seed of Barley are Mendelian.

- (109) COOK, O. F., Suppressed and intensified characters in cotton hybrids. *Bur. Plant Ind. U.S. Dept. Agr., Bull.*, 147: pp 27, '09.

Author finds that in hybrids between the Kekchi cotton and United States Upland varieties the bractlets are suppressed and the lint shortened, while in hybrids between Kekchi and Egyptian cotton the bractlets are enlarged and the lint notably lengthened.

- (110) CORRENS, C., Vererbungsversuche mit blass (gelb) grünen und buntblättrigen bei *Mirabilis*, *Urtica* und *Lunaria*. *Zts. Ind. Abst. u. Vererbgs.*, 1: 291-329, '09. Reprinted in No. (1122).

- (111) CORRENS, C., Zur Kenntnis der Rolle von Kern und Plasma bei der Vererbung. *Zts. Ind. Abst. u. Vererbgs.*, 2: 331-340, '09. Reprinted in No. 1122.

Interpreting the mode of inheritance of the albomaculata type of *Mirabilis*.

- (112) EMERSON, R. A., Factors for mottling in beans. *Ann. Rept. Amer. Breed. Assoc.*, 5: 368-376, '09.

Author suggests that two genes are concerned in the production of mottling in beans.

- (113) EMERSON, R. A., Inheritance of color in the seeds of common bean, *Phaseolus vulgaris*. *Ann. Rept. Nebraska Agr. Exp. Sta.*, 22: 67-101, '09.

Giving full account of the subject.

- (114) FRUWIRTH, C., Spaltungen bei Folgen von Bastardierung und von spontaner Variabilität. *Arch. Rass. u. Ges. Biol.*, 6: 433-469, '09.

Author observes segregation of characters in his individual selection experiments with lupines, beans and peas.

- (115) GREGORY, R. P., The forms of flowers in *Valeriana dioica* L. *Jour. Linn. Soc.*, 39: 91-104, '09.
Describing the four types of flower in this species: short-styled male, long-styled male, hermaphrodite and female; crosses being made between them.
- (116) HURST, C. C., Inheritance of albinism in orchids. *Gard. Chron.*, 45: 81-82, '09. Reprinted in No. (1268).
Recording cases of production of color by crossing albinos.
- (117) LOCK, R. H., A preliminary survey of species crosses in the genus *Nicotiana* from the Mendelian standpoint. *Ann. Roy. Bot. Gard.*, 4: 195-227, '09.
On the inheritance of color in pollen-grains and flowers, and shape of the corolla in *Nicotiana*.
- (118) MARRYAT, D. C. E., Hybridisation experiments with *Mirabilis Jalapa*. *Rept. Evol. Com. Roy. Soc.*, Rept. 5: 32-50, '09.
Determining genes controlling inheritance of flower color in *Mirabilis*.
- (119) NILSSON-EHLE, H., Kreuzungsuntersuchungen an Hafer und Weizen. *Lund Univ. Årsk. N. F.*, 5: 1-122, '09.
Full account of cross-experiments with oats and wheats. Characters observed are: glume color in oats, glume and grain color in wheats, ligule character in oats, panicle type in oats, ear-density in wheats, etc.
- (120) SHOEMAKER, D. N., A study of leaf characters in cotton hybrids. *Ann. Rept. Amer. Breed. Assoc.*, 5: 116-119, '09.
The difference between the Upland type and the okra-leaved type is shown to be monogenic.
- (121) SHULL, G. H., *Bursa bursa-pastoris* and *Bursa Heegeri*: Bio-types and hybrids. *Carneg. Inst. Wash. Publ.*, 112: pp 57 '09.
On the inheritance of leaf shape and capsule form in *Capsella*-crosses.
- (122) STOK, J. E. VAN DER, Mededeelingen omtrent kruisings proeven I, II. *Teysmannia*, 20: 735-738, 780-794, '09. Rev. in *Bot. Cbl.*, 114: 453.
On the inheritance of grain length and awning in *Oryza*.
- (123) STOK, J. E. VAN DER, Onderzoekingen omtrent de bastaard-producten uit de kruisings der rijstvormen R. 731 (moeder) en R. 733 (vader). *Teysmannia*, 20: 652-667, '09. Rev. in *Bot. Cbl.*, 114: 453.
On the inheritance of type of panicle, productiveness, weight, length and width of grains, etc. in *Oryza*.
- (124) WEISS, F. E., Note on the variability in the color of the flowers of a *Tropaeolum* hybrid. *Mem. Lit. Phil. Soc.*, 54: pp 5, '09.

Observations on the offspring raised from selfing a *Tropaeolum* plant which bore both yellow and red flowers.

- (125) WHELDAL, M., Further observations on the inheritance of flower-colour in *Antirrhinum majus*. *Rept. Evol. Com. Roy. Soc.*, Rept. 5: 1-26, '09.

On the genes controlling inheritance of flower color in *Antirrhinum*.

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- (126) BACCARINI, P., Intorno al comportamento di una razza ibrida di piselli. *Nuov. Giorn. Bot. Ital.*, 17: 329-347, '10. Rev. in *Bot. Jahresber.*, 1910: 427.

Observations on inheritance of color in flowers and seeds in *Pisum arvense* × *P. sativum*.

- (127) BAUR, E., Vererbungs- und Bastardierungsversuche mit *Antirrhinum*. *Zts. Ind. Abst. u. Vererbgs.*, 3: 34-98, '10.

Full account of inheritance of flower color, flower form, and leaf color in the snapdragon. Thirteen genes are described.

- (128) BRAINERD, E., The evolution of new forms in *Viola* through hybridism. *Amer. Nat.*, 44: 229-236, '10.

Author recognizes 66 spontaneous hybrids between various wild *Viola* species. Segregation of several characters is observed from breeding of these hybrids.

- (129) CORRENS, C., Der Uebergang aus dem homozygotischen in einen heterozygotischen Zustand im selben Individuum bei buntblättrigen und gestreiftblühenden *Mirabilis*-Sippen. *Ber. Deut. Bot. Ges.*, 28: 418-434, '10.

On the relationship of variegated to normal leaves and also of striped to self-colored flowers in *Mirabilis*.

- (130) EAST, E. M., A Mendelian interpretation of variation that is apparently continuous. *Amer. Nat.*, 44: 65-82, '10.

On the inheritance of the number of rows in the maize cob.

- (131) EAST, E. M., Inheritance in potatoes. *Amer. Nat.*, 44: 424-430, '10.

On the inheritance of color in the stem, flowers, and tubers, shape of tubers and depth of the eye.

- (132) EMERSON, R. A., The inheritance of sizes and shapes in plants. A preliminary note. *Amer. Nat.*, 44: 739-746, '10.

Recording experiments on inheritance of several quantitative characters, such as size of grains and height of stem of maize, size and shape of summer squashes and gourds, etc.

- (133) HENRY, A., On elm-seedlings showing Mendelian results.
Jour. Linn. Soc., 39: 290-300, '10.

The Huntingdon elm (*Ulmus vegeta*) is considered to be the F₁ hybrid between *U. glabra* and *U. montana*. This plant yields both kinds of seedlings, with opposite leaves and with alternate leaves in a 3:1 ratio.

- (134) HERIBERT-NILSSON, E., Jakttagelser öfver descendentera of en spontan artbastard (*Lappa officinalis* L. $\times$ *tormentosa* L.)
Bot. Notis., 1910: 265-302, '10. Rev. in *Zts. Ind. Abst. u. Vererbgs.*, 5: 194.

On the inheritance of color in involucular sepals in the *Lappa*-cross.

- (135) HURST, C. C., Mendel's law of heredity and its application to horticulture. *Jour. Roy. Hort. Soc.*, 36: 22-52, '10. Reprinted in No. (1268).

Reviewing Mendel's work, and recording Mendelian characters in some plants, chiefly in sweet pea and snapdragon and also cases of production of color by crossing two albino orchids.

- (136) KEEBLE, F., AND C. PELLEW, White flowered varieties of *Primula sinensis*. *Jour. Genetics*, 1: 1-5, '10.

Describing a recessive white flowered variety with red stems ('Snow King'), as well as a dominant white primula with green stems ('Pearl King').

- (137) KEEBLE, F., AND C. PELLEW, The mode of inheritance of stature and of time of flowering in peas (*Pisum sativum*).
Jour. Genetics, 1: 47-56, '10.

Recording crosses between two half-dwarfish varieties of *Pisum*, differing in their time of flowering.

- (138) KEEBLE, F., C. PELLEW AND W. N. JONES, The inheritance of peloria and flower-colour in foxgloves (*Digitalis purpurea*).
New Phytologist, 9: 68-77, '10.

On the genic analysis of characters mentioned in the title.

- (139) PIPER, C. V., AND W. J. MORSE, The soy-bean: history, varieties, and field studies. *Bur. Plant Ind. U. S. Dept. Agr., Bull.*, 197: 1-84, '10.

Recording segregation of seed- and flower-color in its natural hybrids.

- (140) PRICE, H. L., Some results of cabbage crosses. *Proc. Soc. Hort. Sci.*, 7: 53-60, '10.

Recording an apparent exception to Mendel's laws, concerning the leaf surface character in some cabbage hybrids.

- (141) SALAMAN, R. N., Male sterility in potatoes, a dominant Mendelian character; with remarks on the shape of the pollen in wild and domestic varieties. *Jour. Linn. Soc.*, 39: 301-312, '10.

On the relations between flower color and pollen sterility in their inheritance.

- (142) SALAMAN, R. N., The inheritance of colour and other characters in the potato. *Jour. Genetics*, 1: 7-46, '10.

On the inheritance of shape of tuber, depth of eye, color of tuber in connection with color of stem in the cultivated potato, and also some observations on inheritance in *Solanum tuberosum* and *S. Maglia*.

- (143) SAUNDERS, E. R., Studies in the inheritance of doubleness in flowers. I. *Petunia*. *Jour. Genetics*, 1: 59-69, '10.

Describing a peculiar mode of inheritance of double flower in *Petunia*.

- (144) SHULL, G. H., Color inheritance in *Lychnis dioica*, L. *Amer. Nat.*, 44: 83-91, '10.

On the genes controlling inheritance of flower color in *Lychnis*.

- (145) SHULL, G. H., Inheritance of sex in *Lychnis*. *Bot. Gaz.*, 40: 110-125, '10.

- (146) STOK, J. E. VAN DER, Mededeelingen omtrent kruisingsproeven. *Teysmannia*, 21: 118-124, '10. Rev. in *Bot. Cbl.*, 114: 454.

On the color inheritance in *Ricinus*, *Capsicum* and *Arachis*.

- (147) STOLL, PH. H., Weizenbastard. *Deutsch. Landw. Presse*: p. 144, '10.

Observations on F_1 & F_2 of a cross between two varieties of wheats, concerning glume color, height of plant, hairing on glumes, shape of glumes and paleas, etc.

- (148) THODAY (SYKES), M. G., AND D. THODAY, On the inheritance of the yellow tinge in sweet pea colouring. *Proc. Phil. Soc.*, 16: 71-84, '10.

On the genes for flower color, especially yellow pigment.

- (149) VILMORIN, PH. DE, Recherches sur l'hérédité mendélienne. *Compt. Rend. Acad. Sci.*, 151: 548-551, '10.

On the inheritance of tendril character ('normal' vs. *acacia*) and leaf color (presence vs. absence of bloom) in peas, and also relationship of tendril character to seed surface form.

- (150) WHELDALE, M., Die Vererbung der Blütenfarbe bei *Antirrhinum majus*. *Zts. Ind. Abst. u. Vererbgs.*, 3: 321-333, '10.

The genes established by the author are compared with those of BAUR. See No. (127).

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- (151) BACCARINI, P., Intorno al comportamento di una razza ibridi di piselli, II. *Nuov. Giorn. Bot. Ital.*, 18: 379-394, '11. Rev. in *Bot. Jahresber.*, 1911: 981.
On the inheritance of length of stem, flower color and certain seed coat characters in *Pisum arvense* × *P. sativum*.
- (152) BALLS, W. L., Mendelian inheritance in hybrids of Upland and Egyptian cotton. *Ann. Rept. Amer. Breed. Assoc.*, 6: 254-267, '11.
Giving a brief summary of the author's extensive work on cotton-crosses.
- (153) BALLS, W. L., The inheritance of measurable characters in hybrids between reputed species of cotton. *VI^e Conf. Internat. Génétique*: 429-440, '11.
On the inheritance of the number of loculi in the ovary, the weight of seeds and the length of the lint.
- (154) BATESON, W., AND R. C. PUNNETT, On gametic series involving reduplication of certain terms. *Jour. Genetics*, 1: 293-302, '11. *Verh. Naturf. Ver. Brünn*, 49: 324-335, '11.
An account of partial repulsion between the genes N and F, and between B and L (see the text) in *Lathyrus* is given.
- (155) BATESON, W., AND R. C. PUNNETT, On the interrelations of genetic factors. *Proc. Roy. Soc.*, 84: 3-8, '11.
With similar contents as in No. (154).
- (156) BATESON, W., AND PUNNETT, Reduplication of terms in series of gametes. *IV^e Conf. Internat. Génétique*: 99-100, '11.
With similar contents as in No. (154).
- (157) BAUR, E., Untersuchungen über die Vererbung von Chromatophorenmerkmalen bei *Melandryum*, *Antirrhinum* und *Aquilegia*. *Zts. Ind. Abst. u. Vererbgs.*, 6: 81-102, '11.
On the Mendelian inheritance of several chlorophyll defects in these plants and *Pelargonium*, and also non-Mendelian chlorophyll characters in *Antirrhinum*, *Primula* and *Pelargonium*, including full discussion on the mode of chlorophyll inheritance in plants.
- (158) BAUR, E., Ein Fall von Faktorenkoppelung bei *Antirrhinum majus*. *Verh. Naturf. Ver. Brünn*, 49: 130-138, '11.
On the partial coupling involving two genes for flower color, F (red) and G ('picturatum').
- (159) BELLAIR, G., Recroisées entre elles deux espèces qui se sont dégagées d'un hybride n'obéissent plus à la loi mendélienne de la dominance. *IV^e Conf. Internat. Génétique*: 201-203, '11.
Recording crosses between *Nicotiana sylvestris* and *N. Tabacum*.

- (160) BELLING, J., Second generation of the cross between Velvet and Lyon beans. *Florida Agr. Exp. Sta., Rept. for 1911*: 82-104, '11.

On the inheritance of various characters of *Stizolobium*: time of flowering, length of pod and seed, color of flower, pubescence on pod, dehiscence of pod and marbling pattern of seed coat.

- (161) BLARINGHEM, L., Sur l'hérédité en mosaïque. *IV^e Conf. Internat. Génétique*: 101-151, '11.

Describing cases of mosaic inheritance in plants, e.g. in *Hordeum*, *Pirus Belberiana*, and sterile hybrids between *Pirus* and *Sorbus*, etc.

- (162) BURTT-DAVY, J., Inheritance of row-numbers in maize-ears. *Nature*, 86: 347-348, '11.

Giving a short account on the subject in the title.

- (163) COLGAN, N., On the inheritance of pitted leaf-blotchings in *Arum maculatum*. *Irish. Nat.*, 20: 210-217, '11. Cited by ONSLOW in No. (1294).

- (164) COLLINS, G. N., AND J. H. KEMPTON, Inheritance of waxy endosperm in hybrids of Chinese maize. *IV^e Conf. Internat. Génétique*: 347-357, '11.

F₂ endosperm characters from the cross of Chinese maize (waxy) × American maize (sweet), consists of starchy, waxy, and sweet endosperms in a ratio of 9:3:4. Also observations on relationship of these endosperm textures to weight of seed.

- (165) EAST, E. M., AND H. K. HAYES, Inheritance in maize. *Connecticut Agr. Exp. Sta., Bull.*, 167: pp. 142 '11.

Giving a full account of Mendelian inheritance in maize. Observations are made on color and texture of endosperm, color of aleurone layer and cob, certain ear abnormalities, etc.

- (166) EMERSON, R. A., Genetic correlation and spurious allelomorphism in maize. *Nebraska Agr. Exp. Sta., Ann. Rept.*, 24: 59-90, '11.

Discussion and experiments on inheritance of pericarp color in maize.

- (167) EMERSON, R. A., Latent colors in corn. *Ann. Rept. Amer. Breed. Assoc.*, 6: 233-237, '11.

Recording the production of grains with red aleurone layer by mating of purple with white.

- (168) EMERSON, R. A., Production of white bean lacking the factor for total pigmentation—a prophecy fulfilled. *Ann. Rept. Amer. Breed. Assoc.*, 6: 396-397, '11.

The author's further studies on the cross, eyed × white, in bean.

- (169) FRUWIRTH, C., Zur Vererbung morphologischer Merkmale bei *Hordeum distichum nutans*. *Verh. Naturf. Ver. Brünn*, 49: 122-129, '11.

On the inheritance of basal bristle in barleys.

- (170) GREGORY, R. P., On gametic coupling and repulsion in *Primula sinensis*. *Proc. Roy. Soc.*, 84: 12-15, '11.

On the coupling, involving genes for flower color and heterostylism.

- (171) GREGORY, R. P., Experiments with *Primula sinensis*. *Jour. Genetics*, 1: 73-132, '11.

Giving a full account of inheritance of heterostylism, leaf shape, plant habit, doubling of flower, color in flowers and stems. A case of coupling is noted. See No. (170).

- (172) GROTH, B. H. A., The F_1 heredity of size, shape and number in tomato leaves. Part I. Seedlings. *New Jersey Agr. Exp. Sta., Bull.*, 238: 3-38; Part II. Mature plants. *ibid.*, 239: 3-12, '11.

- (173) HAIG-THOMAS, R., *Nicotiana* crosses. *IV^e Conf. Internat. Génétique*: 450-461, '11.

Recording the crosses *N. Sanderae* $\times$ *N. affinis*, *N. sylvestris* $\times$ *N. affinis*, and *N. Sanderae* $\times$ *N. sylvestris*.

- (174) HALSTED, B. D. A study of peppers. *New Jersey Agr. Exp. Sta., Rept. for 1911*: 338-359, '11.

On the inheritance of type of peduncle, color of fruit, and taste of fruit in *Capsicum*.

- (175) HEDRICK, U. P., AND R. WELLINGTON, The hereditary transmission of characters of apples. *Proc. Soc. Hort. Sci.*, 8: 19-30, '11.

Recording observations on F_1 plants from several apple crosses, as to color of skin and flesh, shape, size and taste of fruit.

- (176) HURST, C. C., Mendelian characters in plants, animals and man. *Verh. Naturf. Ver. Brünn*, 49: 192-213, '11. Reprinted in No. (1268).

Giving a list of characters which have been found to be subject to Mendelian law, together with the names of investigators.

- (177) HURST, C. C., The application of the principles of genetics to some practical problems. *IV^e Conf. Internat. Génétique*: 210-221, '11. Reprinted in No. (1268).

On practical problems in culinary peas, sweet peas, orchids, primulas, snapdragons, roses, berberis, etc.

- (178) HUS, H., AND A. W. MURDOCK, Inheritance of fasciation in *Zea Mays* L. *Plant World*, 14: 88-96, '11. Cited by WHITE in No. (478).

- (179) JESENKO, F., Sur un hybride fertile entre *Triticum sativum* ♀ (blé Mold-squarehead) et *Secale cereale* ♂ (seigle de Petkus). *IV^e Conf. Internat. Génétique*: 301-311, '11.
Recording observations on F₁, F₂, and F₃ of the wheat-rye cross.
- (180) JOHANNSEN, W., Om nogle mutationer i rene linier. *Biol. Arbejder tilegnede Eug. Warming*: 127-138, '11. Rev. in *Zts. Pflanz. Zücht.*, 1: 481.
Descriptions of two spontaneous variations occurring in pure line of *Phaseolus vulgaris* are given. One of these variants which is characterized by its broader seeds, gave a segregation in broad, intermediate and normal-sized seeds in the next generation.
- (181) KAJANUS, B., Zur Genetik des Weizens. *Bot. Notis.*, 1911: 293-296. Rev. in *Bot. Cbl.*, 119: 374.
Giving a similar account to that in No. (301).
- (182) LEAKE, H. M., Studies in Indian cotton. *Jour. Genetics*, 1: 205-271, '11.
Characters observed: color in the leaf and flower, form of the leaf, type of branching, glands of the leaf, etc.
- (183) LEAKE, H. M., Experimental studies in Indian cottons. *Proc. Roy. Soc.*, 83: 447-451, '11.
With similar contents to those in No. (182).
- (184) LODEWIJKS, J. A., Erblichkeitsversuche mit Tabak. I. *Zts. Ind. Abst. u. Vererbgs.*, 5: 139-172, '11.
- (185) LODEWIJKS, J. A., Erblichkeitsversuche mit Tabak. II. *Zts. Ind. Abst. u. Vererbgs.*, 5: 285-323, '11.
Part I deals with inheritance of double flowers and a chlorophyll (aurea) character in *Nicotiana tabacum*. Also some observations on gigantism and fasciation. Part II deals with selection experiments on number, length, and width of the leaf.
- (186) LOTSY, J. P., Hybrides entre espèces d'*Antirrhinum*. *IV^e Conf. Internat. Génétique*: 416-427, '11.
Recording species crosses, *A. molle* × *A. majus*, and *A. sempevirens* × *A. majus*.
- (187) NILSSON-EHLE, H., Kreuzungsuntersuchungen an Hafer und Weizen II. *Lunds. Univ. Årskr.*, 7: pp. 84 '11.
Further experiments with wheats. Color of grain, density of ear, and resistance to yellow rust are investigated.
- (188) NILSSON-EHLE, H., Über Entstehung scharf abweichender Merkmale aus Kreuzung gleichartiger Formen beim Weizen. *Ber. Deut. Bot. Ges.*, 29: 65-69, '11.
Account of inheritance of grain color in wheat.
- (189) NILSSON-EHLE, H., Über Fälle spontanes Wegfallens eines

Hemmungsfaktors beim Hafer. *Zts. Ind. Abst. u. Vererbgsst.*, 5: 1-37, '11.

Recording the occurrence of a spontaneous variation showing certain wild characters in breeding of cultivated oats, giving its analysis.

- (190) NILSSON-EHLE, H., Spontanes Wegfallen eines Farbfaktors beim Hafer. *Verh. Naturf. Ver. Brünn*, 49: 139-156, '11.

On the production of gray grains as the result of the loss of the black-gene.

- (191) NILSSON-EHLE, H., Méndélisme et acclimatation. *IV^e Conf. Internat. Génétique*: 156-157, '11.

On the inheritance of precocity in wheats and oats, and of cold-resistance in winter wheats.

- (192) ORTON, W.A., The development of disease resistant varieties of plants. *IV^e Conf. Internat. Génétique*: 247-265, '11.

Giving an account of experiments on wilt-resistance in cottons, cow-peas, watermelons and potatoes.

- (193) PEARL, R., AND M. BARTLETT, The Mendelian inheritance of certain chemical characters in maize. *Zts. Ind. Abst. u. Vererbgsst.*, 6: 1-28, '11.

Giving analysis of several chemical characters in a cross, yellow starch maize ♀ × white sugary maize ♂.

- (194) POLE-EVANS, J.B., South African cereal rusts with observations on the problem of breeding rust-resistant wheats. *Jour. Agr. Sci.*, 4: 95-104, '11.

On the behavior of wheat hybrids to yellow rust.

- (195) PRICE, H. L., Inheritance in cabbage hybrids. *Ann. Rept. Virginia Polytec. Inst. Agr. Exp. Sta.* for 1911 and 1912: 240-257, '11-12. Cited by HAYES AND GARBER in No. (792).

- (196) RÜMKE, K.V., Étude sur le coloris des grains chez le seigle. *IV^e Conf. Internat. Génétique*: 332-335, '11.

- (197) SALAMAN, R. N., Studies in potato breeding. *IV^e Conf. Internat. Génétique*: 373-376, '11.

On the inheritance of shape and color of tuber, depth of eye, and resistance to disease in potatoes.

- (198) SAUNDERS, C. E., Production de variétés de blé de haute valeur boulangère. *IV^e Conf. Internat. Génétique*: 290-299, '11.

Suggestion is made that baking strength of wheat grains is governed by a number of genes.

- (199) SAUNDERS, E. R., The breeding of double flowers. *IV^e Conf. Internat. Génétique*: 397-405, '11.

On the inheritance of doubleness in *Matthiola* flowers.

- (200) SAUNDERS, E. R., Further experiments on the inheritance of

'doubleness' and other characters in stocks. *Jour. Genetics*, 1: 303-376, '11.

See No. (199). Also recording the inheritance of branching and pigmentation in *Matthiola*.

- (201) SAUNDERS, E. R., On inheritance of a mutation in the common foxglove (*Digitalis purpurea*). *New Phytologist*, 10: 49-63, '11.

On the inheritance of glabrousness of stem, heptandra-variation and color in flowers in this plant.

- (202) SHULL, G. H., Defective inheritance-ratios in *Bursa* hybrids. *Verh. Naturf. Ver. Brünn*, 49: 157-168, '11.

On the inheritance of form of the leaf and capsule in *Capsella*-crosses.

- (203) SHULL, G. H., Reversible sex-mutants in *Lychnis dioica*. *Bot. Gaz.*, 52: 329-368, '11.

On further observations on hermaphroditism in *Lychnis*.

- (204) SPILLMAN, W. J., Inheritance of 'eye' in *Vigna*. *Amer. Nat.*, 45: 513-523, '11.

On the genic analysis of several 'eye' patterns in cowpea.

- (205) SUTTON, A. W., Compte rendu d'expériences de croisements faites entre le pois sauvage de Palestine et les pois de commerce dans le but de découvrir entre eux quelque trace d'identité spécifique. *IV^e Conf. Internat. Génétique*: 358-367, '11.

A *Pisum*-form found in Palestine has several peculiarities: weak stem, serrate stipules and leaflets, self-magenta flowers, colorless axils, obtuse pods containing a white woolly substance. Crosses are made between these peas and commercial peas.

- (206) TAMMES, T., Das Verhalten fluktuierende variierender Merkmale bei der Bastardierung. *Rec. Trav. Bot. Néerl.*, 8: 201-286, '11.

Experiments with several cultivated and wild species and varieties of *Linum*. Genes for flower color, length and width of petals, size of seed, dehiscence of pods, and hairing on septa of capsule considered.

- (207) TSCHERMAK, E. v., Examen de la théorie des facteurs par le recroisement méthodique des hybrides. *IV^e Conf. Internat. Génétique*: 91-95, '11.

Giving brief account of inheritance of flower color and seed coat spotting in *Pisum*, and of flower color in *Matthiola* is given.

- (208) TSCHERMAK, E. v., Über die Vererbung bei Blütezeit bei Erbsen. *Verh. Naturf. Ver. Brünn*, 49: 169-191, '11.

Giving digenic interpretation of the results of crossing between early and late varieties of *Pisum*.

- (209) VILMORIN, PH. DE, *Pisum*. IV^e Conf. Internat. Génétique: p 51, '11.

Remarks on the inheritance of several characters in *Pisum*.

- (210) VILMORIN, PH. DE, Étude sur le caractère 'adhérence des grains entre eux' chez le pois 'chenille'. IV^e Conf. Internat. Génétique: 368-372, '11.

On the inheritance of adherent vs. free seeds in the pod and presence vs. absence of bloom on the leaf in peas.

- (211) VILMORIN, PH. DE, AND W. BATESON, A case of gametic coupling in *Pisum*. *Proc. Roy. Soc.*, 84: 9-11, '11.

On the relationship of the gene for seed-surface form to that for the acacia type.

- (212) WEISS, F. E., Reserches on heredity in plants. *Mem. Lit. Phil. Soc.*, 56: 1-12, '11-'12.

On the inheritance of color in *Anagallis*-flowers.

- (213) WESTGATE, V., Color inheritance in the petunia. *Ann. Rept. Amer. Breed. Assoc.*, 6: 459-462, '11.

Recording crosses with red and white *Petunia*.

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- (214) BALLS, W. L., The cotton plant in Egypt, studies in physiology and genetics. London, '12.

A chapter is devoted to inheritance in cotton.

- (215) BATCHELER, L. D., Carnation breeding. *Ann. Rept. Amer. Breed. Assoc.*, 7: 199-205, '12.

Remarks on inheritance of the double flower in the carnation.

- (216) BAUR, E., Vererbungs- und Bastardierungsversuche mit *Antirrhinum*. II. Faktorenkoppelung. *Zts. Ind. Abst. u. Vererbgs.*, 6: 201-216, '12.

On the coupling involving genes for flower color in *Antirrhinum*, and also coupling involving chlorophyll genes in *Aquilegia*.

- (217) BAUR, E., Ein Fall von geschlechtsbegrenzter Vererbung bei *Melandrium album* (Kleinere Mitteilung). *Zts. Ind. Abst. u. Vererbgs.*, 8: 335-336, '12.

Giving a brief account of sex-linked inheritance in *Melandrium*, the first example of this kind found in the plant.

- (218) BEACH, S. A., AND T. J. MANEY, Mendelian inheritance in *Prunus* hybrids. *Ann. Rept. Amer. Breed. Assoc.*, 7: 214-226, '12.

Describing observations on inheritance of several characters in *Prunus*: color of foliage, form of leaves, persistence of stipules, habit of tree growth, and immunity to plant lice.

- (219) BELLING, J., Third generation of the cross between Velvet and Lyon beans. *Florida Agr. Exp. Sta., Rept. for 1912*: 115-127, '12.

The author's further observations on *Stizolobium*-crosses. See No. (160).

- (220) BIFFEN, R. H., Studies in the inheritance of disease resistance. II. *Jour. Agr. Sci.*, 4: 421-429, '12.

The author's further observations (up to F_3) on the inheritance of resistance to yellow rust in several wheat-crosses. Also some experiments on the inheritance of resistance to *Claviceps purpurea* in wheat.

- (221) BRAINERD, E., Violet hybrids between species of the palmate group. *Bull. Torrey Bot. Club*, 39: 85-97, '12. Rev. in *Zts. Ind. Abst. u. Vererbgsst.*, 9: 352.

- (222) BURTT-DAVY, J., Observations on the inheritance of characters in *Zea Mays*. *Trans. Roy. Soc. South Africa*, 2: 261-272, '12.

On the inheritance of red pigment in aleurone layer and pericarp, and content of starch and sugar in grains. Also recording F_1 ears in crosses, 8 rowed $\times$ 18 rowed.

- (223) COMPTON, R. H., Preliminary note on the inheritance of self-sterility in *Reseda odorata*. *Proc. Phil. Soc.*, 17: 7, '12-'14.

On the inheritance of selfsterility, and also of anthocyanin in pollen.

- (224) CORRENS, C., Sordago, ein nach den Mendel'schen Gesetzen vererbte Blattkrankheit. *Verh. Ges. Deutsch. Naturf. u. Ärzte*, 84: 250-252, '12. Reprinted in No. (1122).

Giving an account of heritable disease found in *Mirabilis*.

- (225) DORSEY, M. J., Variation studies of the venation angles and leaf dimensions in *Vitis*. *Ann. Rept. Amer. Breed Assoc.*, 7: 227-250, '12.

The author finds that the angle formed by the midrib and the next large lateral vein is a highly constant character in several *Vitis* species. Cross-experiments show the large angle to be dominant.

- (226) EAST, E. M., Inheritance of color in the aleurone cells of maize. *Amer. Nat.*, 46: 363-365, '12.

Giving a brief account of genes controlling the color of aleurone cell.

- (227) EMERSON, R. A., The inheritance of certain 'abnormalities' in maize. *Ann. Rept. Amer. Breed. Assoc.*, 8: 385-399, '12.

On the inheritance of dwarfs, yellow leaves, white seedlings, erect leaves, irregular kernel rows, fasciated ears, etc.

- (228) EMERSON, R. A., The inheritance of the ligule and auricles of corn-leaves. *Nebraska Agr. Exp. Sta., Ann. Rept.*, 25: 81-88, '12.

On the inheritance in crosses between a race having no ligule and auricles and a normal variety.

- (229) EMERSON, R. A., The inheritance of certain forms of chlorophyll-reduction in corn-leaves. *Nebraska Agr. Exp. Sta., Ann. Rept.*, 25: 89-105 '12.

Describing several chlorophyll defects and analyzing their inheritance in corn.

- (230) EMERSON, R. A., The unexpected occurrence of aleurone colors in F_1 of a cross between non-colored varieties of maize. *Amer. Nat.*, 46: 612-615, '12.

Crosses between two white varieties gave in F_2 white, purple and red in a proportion of 530 : 75 : 21. Four genes were assumed to explain the result.

- (231) FINLOW, R. S., AND I. H. BURKILL, The inheritance of red colour, and the regularity of self-fertilization, in *Corchorus capsularis*, LINN.,—the common jute plant. *Mem. Dept. Agr. Ind. Bot. Ser.*, 4: 73-92, '12.

On the inheritance of pigment in stem and leaf.

- (232) FRUWIRTH, C., Spontane vegetative Bastardspaltung. *Arch. Rass. u. Ges. Biologie*, 9: 1-7, '12.

The author found that wheat plants heterozygous in awned condition often showed vegetative segregation for this character.

- (233) FRUWIRTH, C. Zur Züchtung der Kartoffel. *Deutsch. Landw. Presse*, 39: 551-552, 565-567 '12.

On the inheritance of color in tubers, flesh, and flowers and of shape of tuber in potatoes.

- (234) GILBERT, A. W., A Mendelian study of tomatoes. *Ann. Rept. Amer. Breed. Assoc.*, 7: 167-188, '12.

On the inheritance of color, size, and shape of fruit, and of stature in the garden tomato.

- (235) GOODSPEED, T. H., Quantitative studies of inheritance on *Nicotiana* hybrids. *Univ. Calif. Publ. Bot.*, 2: 87-168, '12.

On the inheritance of seed weight in *Nicotiana tabacum* (*virginica* × *macrophylla*) and of corolla diameter in crosses with three varieties of *N. acuminata*.

- (236) GROTH, B. H. A., The F_1 heredity of size, shape and number in tomato fruits. *New Jersey Agr. Exp. Sta., Bull.*, 242: pp 39, '12.

Observation on size and shape of fruit, number of loculation, and hairing on the epidermis in the F_1 of crosses. Pubescent (♀) and glabrous (♂) fruits gave glabrous fruit as the result of xenia.

- (237) HAYES, H. K., Correlation and inheritance in *Nicotiana tabacum*. *Connecticut Agr. Exp. Sta., Bull.*, 171: pp 45 '12.

On the inheritance of several quantitative characters in crosses among five varieties of tobacco. Characters observed are: height of plant;

number of leaves per plant ; area, width, and length of leaves. Also relationship between them.

- (238) HAYES, H. K., Inheritance in corn. *Connecticut Agr. Exp. Sta., Rept. for 1911* : 407-425, '12.

On the inheritance of endosperm texture, color in endosperm, pericarp and cob, certain abnormal types and several quantitative characters.

- (239) HEDRICK, U. P., AND R. WELLINGTON, On experiment in breeding apples. *New York Agr. Exp. Sta., Bull.*, 350 : 141-186, '12.

On the inheritance of color in skin and flesh, shape and size of fruit, and flavor in a number of crosses in apples.

- (240) HERIBERT-NILSSON, N., Die Variabilität der *Oenothera Lamarckiana* und das Problem der Mutation. *Zts. Ind. Abst. u. Vererbgs.*, 8 : 89-231, '12.

On the inheritance of anthocyanin in leaf-nerves, chlorophyll color of leafblades, height of plant, number of stigmas, and shape of corolla in *Oenothera Lamarckiana*. A pleiotropic effect of the color (anthocyanin) gene is observed.

- (241) HERIBERT-NILSSON, N., Ärftlighetsförsök med blomfärgen hos *Anagallis arvensis*. *Bot. Notis.*, 1912 : 229-235, '12. Rev. in *Bot. Cbl.*, 122 : 452.

On the inheritance of color in *Anagallis*-flowers.

- (242) HILDEBRAND, F., Ueber die in den verschiedenen Jahrgängen eingetretenen Färbungsverschiedenheiten bei den Blättern von Bastarden zwischen *Haemanthus tigrinus* mass. und *Haemanthus coccineus* fem. *Beih. Bot. Cbl.*, 28 : 66-89, '12.

On peculiar inheritance of spotting on the leaves in this species cross.

- (243) HOWARD, A., AND L. C., HOWARD, On the inheritance of some characters in wheat I. *Mem. Dept. Agr. India, Bot. Ser.*, 5 : 1-47, '12.

On the inheritance of awning, chaff-hairing, color in grain, glume and awn, texture of endosperm, shattering habit, and standing power of culm.

- (244) HUS, H., Inheritance in *Capsella*. *Science N.S.*, 35 : 159, '12.

Giving a brief account of inheritance of leaf form in *Capsella*.

- (245) JONES, W.N., Species hybrids of *Digitalis*. *Jour. Genetics*, 2 ; 71-88, '12.

Observations on F₁ inheritance of several characters in hybrids (sterile), *D. purpurea* and *D. grandiflora*.

- (246) KAJANUS, B., Genetische Studien an *Beta*. *Zts. Ind. Abst. u. Vererbgs.*, 6 : 137-139. (Correction : p. 268). '12.

On the inheritance of form and color of root.

- (247) KAJANUS, B., Genetische Studien an *Brassica*. *Zts. Ind. Abst. u. Vererbgs.*, 6: 217-237, '12.

Suggestion as to the genes controlling inheritance of root color in *B. Napus*; of length, color and surface form of root in *B. rapa*. Also observations on F_1 , *Napus* $\times$ *rapa*.

- (248) KAJANUS, B., Polyphyllie und Fasciation bei *Trifolium pratense* L. *Zts. Ind. Abst. u. Vererbgs.*, 7: 61-71, '12.

On the inheritance of leaf-lobing in the red clover.

- (249) KAJANUS, B., Die Samenrassen von *Lupinus angustifolius* L. und *Lupinus luteus*, L. *Zts. Ind. Abst. u. Vererbgs.*, 7: 235-239, '12.

On the inheritance of seed coat color in the two species of *Lupinus*.

- (250) KAJANUS, B., Über die Blattzeichnung des Rotklee. *Bot. Notis.*, 1912: 39-43, '12. Rev. in *Bot. Jahresber.*, 1912: 1464.

On the inheritance of leaf-markings in the red clover.

- (251) KAJANUS, B., Mendelistische Studien an Rüben. *Fühlings Landw. Ztg.*, 61: 142-149, '12.

On the inheritance of form and color of root in *Beta vulgaris*, *Brassica Napus* and *Br. rapa*.

- (252) KAJANUS, B., Über die Farben der Blüten und Samen von *Trifolium pratense*. *Fühlings Landw. Ztg.*, 61: 763-776, '12.

On the inheritance of flower color and its relationship to seed color in the red clover.

- (253) KEEBLE, F., Gigantism in *Primula sinensis*. *Jour. Genetics*, 2: 168-188, '12.

On giant plants occurring in 'White Queen Star' and other varieties. Their origin and genetics are discussed.

- (254) KIESSLING, L., Über eine Mutation in einer reinen Linie von *Hordeum distichum* L. *Zts. Ind. Abst. u. Vererbgs.*, 8: 48-78, '12.

Describing in detail a mutant occurring in certain variety of barley and discussing its origin. See reference No. (558).

- (255) LOCK, R.H., Notes on colour inheritance in maize. *Ann. Roy. Bot. Gard.*, 5: 257-264, '12.

Comparing Lock's previous results with those of EAST AND HAYES, and replying to their criticism.

- (256) LOTSY, J.P., Versuche über Artbastarde und Betrachtungen über die Möglichkeit einer Evolution trotz Artbeständigkeit. *Zts. Ind. Abst. u. Vererbgs.*, 8: 325-333, '12.

Species crosses, *Antirrhinum sempervirens* $\times$ *A. majus* and *A. glutinosum* $\times$ *A. majus*, are briefly described.

- (257) MALL, W., Die Ergebnisse verschiedener Getreidebastardierungen. *Deutsch. Landw. Presse*, 39: 2-3, 205-206, '12.

On the inheritance of ear density and grain weight in wheat, and of sterility of lateral florets in barley, and its relations to winter hardiness.

- (258) NILSSON-EHLE, H., Zur Kenntnis der Erbliehkeitsverhältnisse der Eigenschaft Winterfestigkeit beim Weizen. *Zts. Pflanz. Zücht.*, 1: 3-12, '12.

On the inheritance of winter hardiness in *Triticum*.

- (259) RUMKER, K. v., Neue Ergebnisse meiner Züchtungsstudien auf dem Versuchsfelde in Rosenthal. *Zts. d. Landwirtschaftskammer f. d. Provinz Schlesien*: 263-265, '12. Rev. in *Zts. Pflanz. Zücht.*, 1: 245.

On the inheritance of grain color in rye is included.

- (260) SALAMAN, R. N., A lecture on the hereditary characters in the potato. *Jour. Roy. Hort. Soc.*, 38: 34-39, '12.

On the inheritance of color in flowers and tubers, anther sterility, form of berry, shape of tuber, depth of eye, etc. in the potato.

- (261) SAUNDERS, E. R., On the relation of *Linaria alpina* type to its varieties *concolor* and *rosea*. *New Phytologist*, 11: 167-169, '12.

On the color inheritance in *L. alpina* and *L. vulgaris*.

- (262) SAUNDERS, E. R., Further contributions to the study of inheritance of hoariness in stocks (*Matthiola*). *Proc. Roy. Soc.*, 85: 540-545, '12.

On the relationship of the genes for flower color (C and R) to those for hoariness (H and K).

- (263) SHAW, J. K., Heredity, correlation and variation in garden peas. *Massachusetts Agr. Exp. Sta., 24th Ann. Rept. Part I*: 82-101, '12.

On the correlation between height of plant and number of pods per plant and between height of plant and average weight of seeds.

- (264) SHULL, G. H., Inheritance of the heptandra form of *Digitalis purpurea* L. *Zts. Ind. Abst. u. Vererbgs.*, 6: 157-167, '12.

Confirming SAUNDERS' previous results.

- (265) SHULL, G. H., The primary color-factors of *Lychnis* and color-inhibitors of *Papaver Rhoeas*. *Bot. Gaz.*, 54: 120-135, '12.

Presenting cases of dominant white.

- (266) THATCHER, R. W., Dominant and recessive characters in barley and oat hybrids. *Proc. Soc. Prom. Agr. Sci.*, 33: 37-50, '12. Cited by HAYES AND GARBER in No. (792).

- (267) TROW, A. H., On the inheritance of certain characters in the common groundsel—*Senecio vulgaris*, LINN.—and its segregates. *Jour. Genetics*, 2: 239-276, '12.

On the genic analysis of several varieties of *Senecio*. A case of linkage is noted.

- (268) TSCHERMAK, E. v., Bastardierungsversuche an Levkojen, Erbsen und Bohnen mit Rücksicht auf die Faktorenlehre. *Zts. Ind. Abst. u. Vererbgs.*, 7: 81-234, '12.

Giving detailed account on the inheritance of flower color and pubescence in *Matthiola incana* and *glabra* (19 varieties studied), of flower color, leaf axil marks, seed coat color, marbling and wrinkledness of seed in *Pisum sativum* and *arvense* (12 varieties studied), and of seed coat color and pattern in *Phaseolus vulgaris* (17 varieties studied). Also some observations on inheritance of certain quantitative characters, especially seed weight in *Pisum* and *Phaseolus*.

- (269) VILMORIN, PH. DE, Présentation de pois à cosses rouges. *Jour. Soc. Nat. Hort. France*, 13: 571, '12. Cited by WELLENSIEK in No. (1322).

- (270) WEBBER, H. J., Preliminary notes on pepper hybrids. *Ann. Rept. Amer. Breed. Assoc.*, 7: 188-199, '12.

Recording segregation of several characters (see Part I) in F_2 of crosses with some pepper varieties.

- (271) ZADE, A., Die Zwischenformen vom Flughäfer (*Avena fatua*) und Kulturhäfer (*Avena sativa*). *Fühlings Landw. Ztg.*, 61: 369-384, '12.

Suggesting that there is a monogenic difference between these *Avena* species, the heterozygote being an intermediate form.

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- (272) BARLOW, W., Preliminary note on heterostylism in *Oxalis* and *Lythrum*. *Jour. Genetics*, 3: 53-55, '13.

On the experiments with *Oxalis Valdiviana* and *Lythrum Salicaria*.

- (273) BAUR, E., Kreuzungsversuche zwischen Sommerraps und Kohlrübe. *Jahresber. Verein. Angewandte Bot.*, 11: 117-118, '13. Rev. in *Zts. Pflanz. Zücht.*, 2: 247.

Observations on F_1 and F_2 of the cross, *Brassica Napus oleifera* and *B. N. rapifera*.

- (274) BLARINGHEM, L., Phénomènes de xénie chez le blé. *Compt. Rend. Acad. Sci.*, 156: 802, '13.

A cross, *Triticum durum* ♀ × *Tr. vulgare* ♂, gave grains resembling the female parent in size, but the male parent in endosperm texture.

- (275) BLARINGHEM, L., Cas remarquable d'hérédité en mosaïque chez des hybrides d'orges. *Compt. Rend. Acad. Sci.*, 156: 1025-1027, '13.

The author found that *Hordeum distichum nutans* × *H. d. nudum* gave a mosaic inheritance in F_1 and an irregular F_2 segregation into hulled,

half-hulled and naked grains in a proportion of 172 : 16 : 0 in one case, and 92 : 57 : 36 in the other.

- (276) BRAINERD, E., Four hybrids of *Viola pedatifida*. *Bull. Torrey Bot. Club.*, 40 : 249-260, '13.

On the inheritance of leaf form, capsule color and seed color in hybrids between *V. pedatifida*, *V. sororia* and *V. papilionacea*.

- (277) COLLINS, G. N., Heredity of a maize variation. *U. S. Dept. Agr. Plant Ind., Bull.*, 272, '13.

On the inheritance of endosperm color in maize.

- (278) COLLINS, G. N., Mosaic coherence of characters in seeds of maize. *U. S. Dept. Agr. Plant Ind., Circ.*, 132 : 19-21, '13.

Indicating correlation between endosperm texture and aleurone layer color in F_1 hybrids, Chinese (waxy) maize and common (horny) maize.

- (279) COMPTON, R. H., Phenomena and problems of self-sterility. *New Phytologist*, 12 : 197-206, '13.

An account of inheritance of self-sterility in *Reseda odorata*.

- (280) CORRENS, C., Selbststerilität und Individualstoffe. *Biol. Cbl.* 33 : 398-423, '13. Reprinted in No. (1122).

On the inheritance of self-sterility in *Cardamine pratensis*.

- (281) CORRENS, C., Eine mendelnde kälteempfindliche Sippe (f. *delicata*) der *Mirabilis Jalapa*. *Zts. Ind. Abst. u. Vererbgs.*, 10 : 130-135, '13. Reprinted in No. (1122).

Suggestion is made that cold-hardiness in this plant is monogenically dominant to non-hardiness, a fact analogous to winter-hardiness in wheat reported by NILSSON-EHLE.

- (282) EAST, E. M., Inheritance of flower size in crosses between species of *Nicotiana*. *Bot. Gaz.*, 55 : 177-188, '13.

On the crosses between small-flowered *N. forgetiana* and large-flowered *N. alata grandiflora*.

- (283) EMERSON, R. A., and E. M. EAST, The inheritance of quantitative characters in maize. *Nebraska Agr. Exp. Sta. Res. Bull.*, 3, pp. 120, '13.

A full account on the inheritance of several characters in maize: number of rows per ear, length and diameter of ear, weight and size of kernels, number and length of internodes, number of stalks per plant, time of maturity, etc. Also relationship between them.

- (284) FISCHER, H., Ein interessanter *Tropaeolum* Bastard. *Gartenflora*, 62 : 278-282, '13.

On the inheritance of red pigment in *T. pinnatum* (= *T. minus* $\times$ *T. peregrinum*).

- (285) GOLDSCHMIDT, R., Der Vererbungsmodus der gefüllten Lev-

kojenrassen als Fall geschlechtbegrenzter Vererbung. *Zts. Ind. Abst. u. Vererbgs.*, 10: 74-98, '13.

Criticizing SAUNDERS' hypothesis on the inheritance of doubleness in *Matthiola*. Compare reference No. (199).

- (286) GOODSPEED, T. H., Quantitative studies of inheritance in *Nicotiana* hybrids II. *Univ. Calif. Publ. Bot.*, 5: 169-188, '13.

On the author's further experiments on inheritance of flower size in *Nicotiana acuminata*.

- (287) GOODSPEED, T. H., On the partial sterility of *Nicotiana* hybrids made with *N. sylvestris* as a parent. *Univ. Calif. Publ. Bot.*, 5: 189-198, '13.

On F₁ plants of crosses between *N. sylvestris* and several varieties of *N. Tabacum*.

- (288) HAYES, H. K., The inheritance of certain quantitative characters in tobacco. *Zts. Ind. Abst. u. Vererbgs.*, 10: 115-129, '13.

On selection and crossing experiments on number of leaves per plant. Multiple genes are suggested for this character.

- (289) HAYES, H., E. EAST, and E. BEINHART, Tobacco breeding in Connecticut. *Connecticut Agr. Exp. Sta., Bull.*, 176: pp. 68, '13.

With similar contents as No. (288).

- (290) HECTOR, G. P., Notes on the pollination and cross fertilization in the common rice plant, *Oryza sativa* LINN. *Mem. Dept. Agr. India Bot. Ser.*, 6: 1-10, '13.

On the inheritance of pigment in grains and glumes.

- (291) HERIBERT-NILSSON, N., *Oenothera*-problemet. *Svensk. Bot. Tidsk.*, 1913: 1-15, '13. Rev. in *Zts. Pfl. Zücht.*, 3: 242.

On total elimination of the red-veined homozygote in *Oenothera*-crosses.

- (292) HERIBERT-NILSSON, N., Et ärftlighetsexperiment med blomfärgen hos *Centaurea scabiosa*. *Bot. Notis.*, 1913: 264-266, '13. Rev. in *Bot. Cbl.*, 131: 312.

On the inheritance of color in *Centaurea* flowers.

- (293) HERIBERT-NILSSON, N., Potatisförädling och potatisbedömn-
ing. *W. Weibulls Årsbok*, 8: 4-31, '13. Rev. in *Zts. Pfl. Zücht.*, 1: 240.

On the inheritance of flower-percentage (i.e., percentage of flowering plants in offspring), pollen-sterility, color in flowers, tubers and flesh, depth of 'eye', form of tuber, resistance to *Phytophthora*, etc. in potatoes.

- (294) HOLDEFLEISS, P., Über Züchtungs- und Vererbungsfragen bei Rotklee. *Kühn Archiv.*, '13: 81-115. Rev. in *Zts. Pfl. Zücht.*, 1: 479.

On the inheritance of flower- and seed-color, and relations between them in *Trifolium pratense*.

- (295) HOWARD, G. L. C., Studies in Indian tobaccos. No. 3. The inheritance of characters in *Nicotiana tabacum* L. *Mem. Dept. Agr. India Bot. Ser.*, 6: 25-114, '13.

Characters studied are: time of flowering; height of plant; number, arrangement, size and form of leaves; type of leaf-base; leaf-venation; size of corolla, etc.

- (296) HURST, C. C., The application of genetics to orchid breeding. *Jour. Roy. Hort. Soc.*, 38: 412-429, '13. Reprinted in No. (1268).

A list of several kinds of albinos is given, with their genic constitutions (concerning the genes C and R). Also other results in respect to color and pattern are recorded.

- (297) HURST, C. C., 'Rogues' in sweet peas. *Sweet Pea Annual*, '13. Reprinted in No. (1268).

On the inheritance of type and color of flower.

- (298) HURST, C. C., Notes on the Burbage experiments in genetics, 1913. Printed in '13; reprinted in No. (1268).

Including an account of inheritance of several minute variations involving habit of growth, time of flowering, size of flower, and shade of flower color in *Antirrhinum*, and segregation of specific characters in F₂ of *Berberis* hybrids.

- (299) IKENO, S., Studien über die Bastarde von Paprika. *Zts. Ind. Abst. u. Vererbgs.*, 10: 99-114, '13.

On the inheritance of flower color, type of inflorescence and peduncle, fruit length, and pubescence on stem and leaves in *Capsicum*.

- (300) JESENKO, F., Über Getreide-Speziesbastarde (Weizen-Roggen). *Zts. Ind. Abst. u. Vererbgs.*, 10: 311-326, '13.

Recording some Mendelian segregations in wheat-rye hybrids.

- (301) KAJANUS, B., Über einen spontan entstandenen Weizenbastard. *Zts. Pfl. Zücht.*, 1: 13-24, '13.

Recording a spontaneous hybrid, (*turgidum* × *vulgare*) F₂ × *Spelta*, as to inheritance of awning, pubescence, ear-density, glume fitting, bloom on glumes, etc.

- (302) KAJANUS, B., Über die Vererbungsweise gewisser Merkmale der *Beta*- und *Brassica*-Rüben. *Zts. Pfl. Zücht.*, 1: 125-186, 420-463, '13.

On the author's further investigations on inheritance of color and form of root in *Beta* and *Brassica* as well as *Br. Napus* × *rapa*.

- (303) KAJANUS, B., Über die kontinuierlich violetten Samen von *Pisum arvense*. *Fühlings Landw. Ztg.*, 62: 153-160, '13.

- (304) KAJANUS, B., Weiteres über die kontinuierlich violetten Samen von *Pisum arvense*. *Fühlings Landw. Ztg.*, 62: 849-852, '13.

These papers (303) and (304) deal with observations on seeds with purple pigment diffusing continuously over the entire testa.

- (305) KERRAL, MC. A., Some problems of rice improvement in Burma. *Agr. Jour. India*, 111, '13.

In spontaneous hybrids, red color in grains proved to be simply dominant to white.

- (306) NILSSON-EHLE, H., Einige Beobachtungen über erbliche Variationen der Chlorophylleigenschaft bei den Getreidearten. *Zts. Ind. Abst. u. Vererbgs.*, 9: 289-300, '13.

On the inheritance of two chlorophyll-defective types, white and yellow, in rye, also. On the appearance of some chlorophyll variations in barley and oat.

- (307) NORTON, J. B., Methods used in breeding asparagus for rust resistance. *U. S. Dept. Agr. Plant Ind., Bull.*, 263: pp. 60, '13.

The statement is made that rust resistance in asparagus is a heritable character.

- (308) PELLEW, C., Note on gametic reduplication in *Pisum*. *Jour. Genetics*, 3: 105-106, '13.

On 'reduplication' involving the genes for normal (vs. 'Acacia') type and round (vs. wrinkled) seed, confirming VILMORIN AND BATESON's results See (No. 211).

- (309) PUNNETT, R. C., Reduplication series in sweet peas. I. *Jour. Genetics*, 3: 77-103, '13

On 'reduplication' series involving the genes for blue (vs. red) flower color, erect (vs. hooded) standard and long (vs. round) pollen, and also one involving the genes for dark (vs. light) axil, normal (vs. sterile) anthers and normal (vs. cretin) flower.

- (310) SALMON, E. S., On the appearance of sterile "dwarfs" in *Humulus Lupulus* L. *Jour. Genetics*, 3: 195-200, '13.

Giving description of dwarfs occurring among the offspring of crosses of cultivated (♀) with wild (♂) variety.

- (311) SAUNDERS, E. R., On the mode of inheritance of certain characters in double-throwing stocks. A reply. *Zts. Ind. Abst. u. Vererbgs.*, 10: 297-310, '13.

Reply to GOLDSCHMIDT's criticism (see No. (285)) on the subject.

- (312) SZAPYEROW, TH., Die Widerstandsfähigkeit der Panzersorten von *Helianthus annuus* gegen *Orobanche cumana*. *Bull. Angew. Bot.*, 6: 251, '13. Rev. in *Zts. Pfl. Zücht.*, 2: 264.

On the inheritance of resistance to *Orobanche*.

- (313) SHAW, J. K., The inheritance of blossom color in beans. *Massachusetts Agr. Exp. Sta. Bull.*, **25**, pp. 24, '13.

A full account of a series of crosses among 19 varieties of *Phaseolus vulgaris*. Observations are made through four generations, but genic analysis for flower color is not yet given.

- (314) SPILLMAN, W. J., Color correlation in cowpeas. *Science*, N. S., **38**: 302, '13.

On connection between colors in seeds, flowers and vegetative parts.

- (315) STOMPS, T. J., Das *Cruciata*-Merkmal. *Ber. Deut. Bot. Ges.*, **31**: 166-172, '13.

On the inheritance of sepalody of corollas in *Oenothera biennis* and *Epilobium hirsutum*.

- (316) TAMMES, T., Einige Korrelationserscheinungen bei Bastarden. *Rec. Trav. Bot. Néerl.*, **10**: 69-84, '13.

Account of correlation between the following characters of *Linum* (*angustifolium* and *usitatissimum*) in inheritance,— length, width and color of corolla, and length and width of seed.

- (317) TSCHERMAK, E. V., Ueber seltene Getreidebastarde. *Beitr. zur Pflanzenzücht.*, **3**: 49-61. Rev. in *Bot. Obl.*, **132**: 423.

Recording crosses between the wild species and cultivated forms of rye, barley and oat, and those between several cultivated species of wheat.

- (318) VAVILOV (WAWILOFF), N., Über den Weizenbastard *Triticum vulgare* VILL. ♀ × *Triticum monococcum* L. ♂. (In Russian with German résumé). *Bull. Angew. Bot.*, **6**: 1-19. Rev. in *Zts. Pfl. Zücht.*, **1**: 405.

The author succeeded in crossing these two wheat species. The hybrid entirely lacks pollen, but is normal for the female side, and is very susceptible to *Puccinia triticina* and *P. glumarum*, indicating the resistance to these rusts as recessive.

- (319) VILMORIN, PH. DE, Sur une race de blé nain infixable. *Jour. Genetics*, **3**: 67-76, '13.

On the appearance of dwarfish plants in certain wheat varieties and their peculiar mode of inheritance.

- (320) WELLINGTON, R., Inheritance of the russet skin in the pear. *Science*, N. S., **37**: 156-157, '13.

- (321) WELLINGTON, R., Raspberry breeding. *Proc. Soc. Hort. Sci.*, **10**: 155-159, '13.

Observations on inheritance of several characters, such as color in canes and fruits, amount of spines, bloom on canes, etc., are made in the offspring of selfed *Rubus neglectus*, as well as in *R. strigosus* × *R. occidentalis*.

- (322) WHITE, O. E., The bearing of teratological development in *Nicotiana* on theories of heredity. *Amer. Nat.*, 47: 206-228, '13.

On the inheritance of fasciation in *N. tabacum*.

- (323) WICHLER, G., Untersuchungen über den Bastard *Dianthus Armeria* $\times$ *Dianthus deltoides* nebst Bemerkungen über einige andere Artkreuzungen der Gattung *Dianthus*. *Zts. Ind. Abst. u. Vererbgs.*, 10: 177-232, '13.

GÄRTNER obtained hybrids, *D. Armeria* and *D. deltoides*, remaining constant through 10 generations. The author, however, found in F₂, F₃, and F₄ typical segregations in 15 pairs of characters. Certain other *Dianthus*-crosses gave similar results.

1914.

- (324) ANTHONY, R. D., Methods and results in grape breeding. *Proc. Soc. Hort. Sci.*, 11: 81-86, '14.

Giving short accounts of inheritance of self-sterility, sex, color, size and form of berry, season of ripening, and quality of fruit in grapes.

- (325) BELLING, J., A study of semi-sterility. *Jour. Heredity*, 5: 65-73, '14.

On the inheritance of semi-sterility in *Stizolobium*-hybrids.

- (326) BELLING, J., Inheritance in plant hairs. *Jour. Heredity*, 5: 348-360, '14.

Recording experiments on *Stizolobium*-crosses concerning form of hairs on pod.

- (327) BELLING, J., The mode of inheritance of semi-sterility in the offspring of certain hybrid plants. *Zts. Ind. Abst. u. Vererbgs.*, 12: 303-342, '14.

With similar contents as in No. (326).

- (328) BELLING, J., Inheritance of pod pubescence and partial sterility in *Stizolobium* crosses. *Florida Agr. Exp. Sta., Rept.* for 1914: 31-35, '14.

Similar to the preceeding papers in contents.

- (329) BÖRNER, C., Ueber Reblaus-anfällige und immune Reben. *Biol. Obl.*, 34: 1-8, '14.

On the inheritance of resistance to rust in *Vitis*.

- (330) CHAPIN, W. S., Heredity in chimeras. *Jour. Heredity*, 5: 533-546, '14.

Observations on variegated plants of *Amaranthus retroflexus*. Mention is made that probably the inheritance of this character is analogous to that of variegated chimeras of *Pelargonium* found by BAUR.

- (331) CHRISTIE, W., Undersökelse over norsk graaert samt nogen

krydsninger mellem former av den og *Pisum sativum*.
*Beretning om Hedemarkens Amts Forsöksstations Virksom het
 i Aaret 1913*: 29-78, '14. Rev. in *Zts. Pfl. Zücht.*, 2:
 391.

Identifying genes controlling inheritance of pattern in the testa of
Pisum.

- (332) COCKERELL, T. D. A., Suppression and loss of characters in
 sunflowers. *Science*, N. S., 40: 283-285, '14.

On the inheritance of pigment in *Helianthus*-flowers.

- (333) COCKERELL, T. D. A., Sunflower problems. *Science*, N. S., 40:
 708-709, '14.

Giving discussion as to nature of variation which produces red
 pigment in sunflower.

- (334) COLLINS, G. N., and J. K. KEMPTON, Inheritance of endosperm
 texture in sweet $\times$ waxy hybrids of maize. *Amer. Nat.*, 48:
 584-594, '14.

On the author's further observations on the subject. See No. (164).

- (335) COLLINS, G. N., and J. H. KEMPTON, Inheritance of waxy
 endosperm in hybrids with sweet corn. *U. S. Dept. Agr. Plant
 Ind., Circ.*, 120: 21-27, '14.

With similar contents as in No. (334).

- (336) COLLINS, G. N., and J. H. KEMPTON, A hybrid between *Trip-
 sacum* and *Euchlaena*. *Jour. Wash. Acad. Sci.*, 4: 114-117, '14.

Giving description of the completely patroclinous hybrid from this
 cross.

- (337) CONNORS, C. H., Heredity studies with the carnation. *Proc.
 Soc. Hort. Sci.*, 11: 95-100, '14.

Some observations on the inheritance of color in flowers of carnations.

- (338) EAST, E. M., and H. K. HAYES, A gametic analysis of the
 changes produced by selection in experiments with tobacco.
Amer. Nat., 48: 5-48, '14.

An account of inheritance of number of leaves in a cross, Havana $\times$
 Sumatra.

- (339) EMERSON, R. A., The inheritance of a recurring somatic varia-
 tion in variegated ears of maize. *Amer. Nat.*, 48: 87-115, '14.

On the inheritance of red pigment in variegated ears of maize.

- (340) EMERSON, R. A., Multiple factors vs. 'Golden mean' in size
 inheritance. *Science* N. S., 40: 57-58, '14.

Criticizing of GROTH's 'golden mean' hypothesis. Compare No.
 (344).

- (341) ENGLENDOW, F. L., A case of repulsion in wheat. *Proc. Phil.
 Soc.*, 17: 433-435, '14.

On the relationship of glume color to pubescence in inheritance.

- (342) GRAVATT, F., A radish-cabbage hybrid. *Jour. Heredity*, 5: 269-272, '14.

This hybrid was self-sterile. The leaves were nearer to the cabbage parent in size and shape, intermediate in color between the light green of radish and the dark or blue green of cabbage, glabrous like cabbage, more like cabbage in taste, etc.

- (343) GREGORY, R. P., On the genetics of tetraploid plants in *Primula sinensis*. *Proc. Roy. Soc.*, 87: 484-492, '14.

Breeding experiments are made with two tetraploid races of *P. sinensis*. They were sterile in crosses with other diploid races. In course of breeding some recessive types (e.g. *stellata* habit, red flower color, fern leaf) appeared; of these, however, none appeared before F_3 . In addition to these, some peculiar intermediate forms (e.g. those between *sinensis* and *stellata* habit, dominant white and colored flowers, palm leaf and fern leaf) were obtained. These results, with others, were thought to be due to a double set of genes possessed by these tetraploid plants.

- (344) GROTH, B. H. A., The 'golden mean' in the inheritance of size. *Science*, N.S., 39: 581-584, '14.

Observations on inheritance of fruit size in tomatoes.

- (345) HAGEDOORN, A. L., and A. C. HAGEDOORN, Studies on variation and selection. *Zts. Ind. Abst. u. Vererbgs.*, 11: 145-183, '14.

Among others, is made the discussion as to genes which control inheritance of location of seeds in the ripe pod of peas.

- (346) HONING, J. A., Kruisingsproeven met *Canna indica*. *Versl. Kon. Akad. Wet. Amsterdam Afd. Wis- en Naturk.*, 22: 773-779, '14. Rev. in *Bot. Cbl.*, 128: 149.

On the inheritance of pigment in stems, leaves and fruit-papillae of *C. indica*. Also recording a cross, *C. indica* $\times$ *C. glauca*.

- (347) HUS, H., The origin of $\times$ *Capsella Bursa-pastoris arachnoidea*. *Amer. Nat.*, 48: 193-235, '14.

Giving description of a new gene, N, which controls the form of early leaves of *Capsella*.

- (348) IKENO, S., Über die Bestäubung und die Bastardierung von Reis. *Zts. Pfl. Zücht.*, 2: 495-503, '14.

Including account of inheritance of endosperm texture in rice.

- (349) KAJANUS, B., Zur Genetik der Samen von *Phaseolus vulgaris*. *Zts. Pfl. Zücht.*, 2: 377-388, '14.

On the inheritance of pigment in the testa.

- (350) KAJANUS, B., Ueber die Vererbung der Blütenfarbe von *Lupinus mutabilis* SWT. *Zts. Ind. Abst. u. Vererbgs.*, 12: 57-58, '14.

Recording a monogenic difference between blue and white.

- (351) KAPPERT, H., Untersuchungen an Mark-, Kneifel- und Zuckererbsen und ihren Bastarden. *Zts. Ind. Abst. u. Vererbgs.*, 13: 1-57, '14.

Inheritance of seed form in *Pisum*, in connection with type of starch grains. Reference is made to DARBISHIRE's experiment. See No. (92).

- (352) KIESSLING, L., Selektions- und Bastardierungsversuche mit weissbunten Pferdebohnen. *Zts. Pfl. Zücht.*, 2: 313-338, '14.

Recording observations through three generations on crosses of green with chlorophyll-defective plants of *Vicia Faba*.

- (353) KIESSLING, L., Erbanalytische Untersuchungen über die Spelzenfarbe des Weizens. *Landw. Jahresb. für Bayern*, pp. 102-170, '14. Rev. in *Bot. Cbl.*, 126: 472.

On peculiar mode of inheritance of glume color in wheats, including change of dominance. A new genic interpretation is postulated.

- (354) KRISTOFFERSON, K. B., Ueber Bastarde zwischen elementaren Species der *Viola tricolor* und *V. arvensis*. *Bot. Notis.*, 1914: 25-31, '14.

A preliminary account of crosses between several lines of two *Viola* species, referring chiefly to F_1 hybrids.

- (355) LEAKE, H. M., and R. PRASAD, Studies in Indian cottons. Part I. The vegetative characters. *Mem. Dept. Agr. India Bot. Ser.*, 6: 115-150, '14.

On the inheritance of color in the flower and leaf, and of the type of branching in connection with the length of vegetative period.

- (356) LEHMANN, E., Ueber Bastardierungsuntersuchungen in der *Veronica*-Gruppe *agrestis*. *Zts. Ind. Abst. u. Vererbgs.*, 13: 88-175, '14.

Crosses between *V. Tournefortii Aschersoniana* and *V. Corrensiana*. Observations are made through three generations on flower size, leaf size, character of leaf-margin, flower color and flower form.

- (357) LIDFORSS, B., Resumé seiner Arbeiten über *Rubus*. Hinterlassenes Manuskript. *Zts. Ind. Abst. u. Vererbgs.*, 12: 1-13, '14.

Several *Rubus*-crosses are described.

- (358) LUMSDEN, D., Mendelism in melons. *New Hampshire Agr. Exp. Sta. Bull.*, 172: 3-58, '14.

Recording crosses between two varieties of melons, as to the inheritance of color, form and size of fruit, size of seeds, ribbing and netting.

- (359) MALINOWSKI, E., Les hybrides du froment. *Bull. Internat. Acad. Sci. Cracovie, Sér. B.*, 3: 410-450, '14. Rev. in *Bot. Cbl.*, 126: 643.

Recording crosses among several wheat varieties, *Triticum Spelta* × *vulgare*, *Tr. dicoccum* × *Tr. dicoccum*, and *Tr. dicoccum* × *Tr. vulgare*. Segregation as to ear density, grain color, awning, pubescence on glumes, etc.

- (360) MYERS, C. E., Study of the inheritance of size and productiveness in pedigreed strains of tomatoes. *Proc. Soc. Hort. Sci.*, 11: 26-33, '14.

- (361) NILSSON-EHLE, H., Zur Kenntnis der mit der Keimungsphysiologie des Weizens in Zusammenhang stehenden inneren Faktoren. *Zts. Pfl. Zücht.*, 2: 153-187, '14.

On the inheritance of germinating time in connection with grain color in wheats.

- (362) NILSSON-EHLE, H., Ueber einen als Hemmungsfaktor der Begrannung auftretenden Farbfaktor bei Hafer. *Zts. Ind. Abst. u. Vererbgs.*, 12: 36-55, '14.

On the relationship of yellow color in glumes to awning in inheritance.

- (363) PARKER, W. H., Lax and dense-eared wheats. *Jour. Agr. Sci.*, 6: 371-386, '14.

Recording (up to F₄) crosses between a *compactum* variety and two lax-eared varieties.

- (364) RELANDER, L., Einige Beobachtungen über die Produktionsfähigkeit und die Blütezeit der F₁ Generation einiger Erbsenkreuzungen. *Arbeit aus der landwirtschaftlichen Zentralversuchsstation in Finnland, Helsingfors*. 1914: pp 26, '14. Rev. in *Zts. Pfl. Zücht.*, 2: 216.

- (365) RICHARDSON, C. W., A preliminary note on the genetics of *Fragaria*. *Jour. Genetics*, 3: 171-178, '14.

On the inheritance of runners, fruit color, perennials, leaf form and sex in *F. vesca* and garden hybrids.

- (366) SAZYPEROW, T. H., Versuche und Beobachtungen an *Helianthus annuus* L. auf dem Versuchsfeld. (In Russian with German résumé). *Bull. Angew. Bot.*, 7: 543-600, '14. Rev. in *Zts. Pfl. Zücht.*, 3: 380.

On the genes controlling inheritance of color in fruits of *Helianthus*.

- (367) SHULL, G. H., Über die Vererbung der Blattfarbe bei *Melandrium*. *Ber. Deut. Bot. Ges.*, 31: (40)-(80), '14.

Identifying the genes controlling inheritance of several chlorophyll deficiencies in *Melandrium* (*Lychnis dioica*), and giving also descriptions of certain non-Mendelian variegated forms.

- (368) SHULL, G. H., Duplicate genes for capsule form in *Bursa bursa-pastoris*. *Zts. Ind. Abst. u. Vererbgs.*, 12: 97-146, '14.

Demonstrating duplicate genes in crosses, *Capsella bursa-pastoris* and *C. Heegeri*. Analogous cases found in other plants are fully reviewed.

- (369) SHULL, G. H., Sex-limited inheritance in *Lychnis dioica* L. *Zts. Ind. Abst. u. Vererbgs.*, 12: 265-302, '14.

On further analysis of the sex-linked inheritance of narrow-leavedness in *Lychnis*. See No. (217).

- (370) SOUTHWORTH, W., Alfalfa hybridization. *Jour. Heredity*, 5: 448-457, '14.

On the inheritance of height of plant and habit of growth in hybrids, *Medicago sativa* and *M. lupulina*.

- (371) STRAUS, H., Dominanz und Rezessivität bei Weizenbastarden. *Dissert. Göttingen*, 8, pp. 38, '14. Rev. in *Zts. Ind. Abst. u. Vererbgs.*, 19: 139.

Giving description of F_1 hybrids between ten different varieties as to behavior of awning, glume color and pubescence on glumes.

- (372) SUTTON, A. W., Results obtained by crossing a wild pea from Palestine with commercial types. *Jour. Linn. Soc., Bot.*, 42: 427-434, '14.

See No. (205).

- (373) TAMMES, T., Eine Erklärung einer scheinbaren Ausnahme der Mendelschen Spaltungsregel. *Rec. Trav. Bot. Néerl.*, 11: 54-69, '14.

Giving explanation of a defective F_2 ratio in a cross between blue- and white-flowered varieties of *Linum*.

- (374) VAVILOV, N. J., Immunity of fungous disease as a physiological test in genetics and systematics, exemplified in cereals. *Jour. Genetics*, 4: 49-65, '14.

It is stated that the mode of reaction to a definite rust is a character peculiar to each variety of *Triticum* and *Avena*.

- (375) VESTERGAARD, H. A. B., Jagttagelser vedrørende bladgråntløse bygplanter. *Tidsskr. Landb. Plant.*, 21: 151-154, '14. Rev. in *Zts. Pfl. Zücht.*, 3: 56.

On the inheritance of white seedlings in barleys.

- (376) WHITE, O. E., The history of *Nicotiana* II. *Brooklyn Bot. Gard. Mem.* 2, pp. 8, '14.

On the inheritance of fasciated form in *N. Tabacum*.

- (377) WHITE, O. E., Studies of teratological phenomena in their relation to evolution and the problems of heredity. I. A study of certain floral abnormalities in *Nicotiana* and their bearing on theories of dominance. *Amer. Jour. Bot.*, 1: 23-36, '14.

On the inheritance of petalody, pistillody and catacorolla in *Nicotiana*.

1915.

- (378) ANTHONY, R. D., Some results in the breeding of small fruits. *Proc. Soc. Hort. Sci.*, 12: 121-125, '15.

Giving a brief accounts of inheritance of color in fruits, dwarf stature in raspberries, and sex in strawberries.

- (379) ATKINS, W. R. G., and G. O. SHERRARD, The pigments of fruits in relation to some genetic experiments on *Capsicum annuum*. *Sci. Proc. Roy. Dublin Soc.*, 14: 328-335, '15. Rev. in *Bot. Cbl.*, 131: 614.

- (380) BATESON, W., and C. PELLEW, On the genetics of 'rogue' among culinary peas (*Pisum sativum*). *Jour. Genetics*, 5: 13-36, '15.

Description of 'rogues' of pea, and their peculiar mode of inheritance in a series of crosses, type $\times$ rouge and its reciprocal, type $\times$ intermediate, rouge $\times$ rouge, and intermediate $\times$ intermediate.

- (381) BELLING, J., Linkage and semi-sterility. *Amer. Nat.*, 49: 582-584, '15.

Giving a brief account of some experimental results concerning linkage of lateness of flowering time with semi-sterility and also with pigmentation in the testa in *Stizolobium*.

- (382) BELLING, J., Inheritance of mottling of the seed-coat. *Florida Agr. Exp. Sta. Rept. for 1915*: 111-127, '15.

On the genes controlling inheritance of mottling in *Stizolobium*.

- (383) BOND, T. C., On the primary and secondary sex-characters of some abnormal *Begonia* flowers and on the evolution of the monoecious condition in plants. *Jour. Genetics*, 4: 341-352, '15.

Giving observations on *Begonia* varieties showing deviation from the normal monoecious type.

- (384) COCKERELL, T. D. A., An early observation on the red sunflower. *Science, N. S.*, 41: 33-34, '15.

Giving discussion on the origin of the red sunflower, and on relationship of flower-to stem-color.

- (385) COCKERELL, T. D. A., The marking factors in sunflower. *Jour. Heredity*, 6: 542-545, '15.
On the inheritance of pigment in *Helianthus*-flowers.
- (386) CORRENS, C., Über eine nach den Mendel'schen Gesetzen vererbte Blattkrankheit (Sordago) der *Mirabilis Jalapa*. *Jahrb. Wiss. Bot.*, 56: 585-616, '15. Reprinted in No. (1122).
Author's further experiments on the subject. See No. (224).
- (387) CRANE, M. B., Heredity of types of inflorescence and fruits in tomato. *Jour. Genetics*, 5: 1-12, '15.
On the inheritance of fruit shape, type of inflorescence and sterility of anthers in crosses between two varieties of tomato.
- (388) DAHLGREN, K. V. O., Ein Kreuzungsversuch mit *Capsella Heegeri* SOLMS. *Svensk. Bot. Tidsk.*, 9: 397-400, '15.
On the inheritance of capsule shape in *Capsella*.
- (389) DYKES, W. R., Do Mendel's laws hold good for crosses between species? *Gard. Chron.*, 80: 196-197, '15.
Recording crosses between various species of *Iris*. No dominance was found.
- (390) EAST, E. M., The phenomenon of self-sterility. *Amer. Nat.*, 49: 77-87, (A correction, p. 712). '15.
On the self-sterility in crosses between two self-sterile species, *Nicotiana Forgetiana* $\times$ *N. glauca*.
- (391) EAST, E. M., An interpretation of self-sterility. *Proc. Nat. Acad. Sci.*, 1: 95-100, '15.
With similar contents as in No. (390).
- (392) EMERSON, R. A., Anomalous endosperm development in maize and the problem of bud sports. *Zts. Ind. Abst. u. Vererbgs.*, 14: 241-259, '15.
Abnormal grains showing chimera structure of pigment and endosperm texture were produced in F_1 of certain maize crosses. Causation of these abnormalities is discussed.
- (393) FROST, H. B., The inheritance of doubleness in *Matthiola* and *Petunia*. 1. The hypotheses. *Amer. Nat.*, 49: 623-635, '15.
Giving interpretation of SAUNDER's results on inheritance of doubleness in these plants.
- (394) FRUWIRTH, C., Versuche zur Wirkung der Auslese. *Zts. Pfl. Zücht.*, 3: 173-224, 395-451, '15.
Materials used are: *Lens esculenta*, *Phaseolus vulgaris*, *Vicia sativa*, *Pisum arvense*, Soja Max, *Lupinus angustifolius*, *Sinapis alba*, *Avena sativa*, etc. Certain cases of inheritance of seed coat coloration are included.

- (395) GILBERT, A. W., Heredity of colour in *Phlox Drummondii*.
Jour. Agr. Res., 4: 293-302, '15.

On the genes for flower color in *Phlox*.

- (396) GOODSPEED, T. H., Quantitative studies of inheritance in
Nicotiana hybrids III. *Univ. Calif. Publ., Bot.*, 6: 223-231,
'15.

Author's further observations (F_3) on the inheritance of flower size in
Nicotiana acuminata.

- (397) GOODSPEED, T. H., and R. E. CLAUSEN, Factors influencing
flower size in *Nicotiana*, with special reference to question of
inheritance. *Amer. Jour. Bot.*, 2: 332-373, '15.

Observations on length of corolla in the F_1 hybrid from crosses
between varieties of *N. Tabacum* and also *N. Tabacum* $\times$ *N. sylvestris*.

- (398) GREGORY, R. P., Note on the inheritance of heterostylism in
Primula acaulis JACQ. *Jour. Genetics*, 4: 303-304, '15.

- (399) GREGORY, R. P., On variegation in *Primula sinensis*. *Jour.*
Genetics, 4: 305-321, '15.

The author finds that variegated and pale yellowish-green color of
leaves behaves as a non-Mendelian character, being transmitted through
the egg cells only.

- (400) GROTH, B., Some results in size inheritance. *New Jersey Agr.*
Exp. Sta. Bull., 278, pp. 92, '15.

Characters observed are: number, form and size of cotyledons, first
leaves, foliage leaves and fruits of garden tomatoes. Also size (weight)
of fruits in crosses between two varieties of *Solanum nigrum*.

- (401) HALLQVIST, C., Brassicakreuzungen. *Bot. Notis.*, 1915: 97-
112, '15.

On the inheritance of root flesh color (in connection with flower
color) and skin color in *Brassica Napus*, *B. rapa* and their hybrids.
Inheritance of anthocyanin pigmentation in the basal portion of leaf-
stalks is also noted.

- (402) HAYES, H., and E. EAST, Further experiments on inheritance
in maize. *Connecticut Agr. Exp. Sta. Bull.* 188: pp. 31, '15.

Full account of inheritance of endosperm texture in several maize
crosses.

- (403) HEDRICK, U. P., and R. D. ANTHONY, Inheritance of certain
characters of grapes. *Jour. Agr. Res.*, 4: 315-330, '15.

On the inheritance of type of stamens (in connection with self-
sterility), sex, color of fruit skin, quality, size and shape of berry,
season of ripening, etc.

- (404) HENKEMEYER, A., Untersuchungen über die Spaltungen von Weizenbastarden in der F_2 - und F_3 - Generationen. *Jour. Landw.*, 63: 97-124, '15.

Continuation of the work of STRAUS. See No. (371). Segregation as to pubescence and color of glumes and awning.

- (405) HERIBERT-NILSSON, N., Die Spaltungserscheinungen der *Oenothera Lamarckiana*. *Lund. Univ. Årsskr.*, N. F., 12: pp. 131, '15.

On the studies with *O. Lamarckiana* from a Mendelian stand point. Giving explanation of the total elimination of red nerved homozygotes in F_2 from crosses between red- and colorless-nerved varieties.

- (406) HERIBERT-NILSSON, N., Eliminierung der positiven Homozygoten bezüglich der Rotnervigkeit bei *Oenothera Lamarckiana*. *Bot. Not.*, 1915: 23-25, '15.

- (407) HONING, J. A., Kreuzungsversuche mit *Canna*-Varietäten. *Rec. Trav. Bot. Néerl.*, 12: 1-26, '15.

Giving suggestion concerning the genes for pigment in leaves of *Canna*.

- (408) HOOD, G. W., Inheritance in tomatoes. *Proc. Soc. Hort. Sci.*, 12: 87-95, '15.

On the inheritance of dwarfishness in a number of tomato-crosses.

- (409) HOSHINO, Y., On the inheritance of the flowering time in peas and rice. *Jour. Coll. Agr. Tôhoku Imp. Univ.*, Sapporo, 6: 229-288, '15.

Crosses are made between two varieties of early-blooming *Pisum sativum* and a variety of late-blooming *P. arvense*, and between an early-shooting *Oryza sativa* and a late-shooting *O. glutinosa*. Relationship of flower color to earliness in peas.

- (410) HOWARD, A., and G. L. C. HOWARD, On the inheritance of some characters in wheat. II. *Mem. Dept. Agr. India, Bot. Ser.*, 7: 273-285, '15.

Author's further contribution to the genic analysis of awning and pubescence in wheat.

- (411) IKENO, S., À propos d'un type nouveau des plantes variées non-mendéliennes. *Bot. Mag., Tokyo*, 29: 216-221, '15.

Non-Mendelian inheritance of variegation in *Capsicum annuum*.

- (412) KIESSLING, L., Untersuchungen über die Vererbung von Stickstoffgehalt und Korngrösse der zweizeligen nickenden Gerste. *Zts. Pfl. Zücht.*, 3: 81-147, '15.

Selection experiments with pure lines of barleys gave results showing that nitrogen content and seed weight are heritable characters, and there is a positive correlation between them.

- (413) LEIGHTY, C. E., Natural wheat-rye hybrids. *Jour. Amer. Soc. Agron.*, 7: 209-216, '15.
- (414) MILES, F. C., A genetic and cytological study of certain types of albinism in maize. *Jour. Genetics*, 4: 193-214, '15.
On the inheritance of pure white, yellowish-white and 'golden' (aurea) types of maize.
- (415) NOHARA, S., Genetical studies on *Oxalis*. *Jour. Coll. Agr., Imp. Univ. Tokyo*, 6: 165-181, '15.
Inheritance of purple pigment in flowers and leaves of *O. corniculata*.
- (416) NORTON, J. B., Inheritance of habit in the common bean. *Amer. Nat.*, 49: 547-561, '15.
Identifying the genes controlling inheritance of growth habit and stem length in *Phaseolus*.
- (417) RASMUSON, H., Zur Vererbung der Blütenfarben bei der Balsamine. *Bot. Notis.*, 1915: 79-83, '15.
Giving suggestion as to the genes for flower color in the balsam.
- (418) REINKE, J., Eine bemerkenswerte Knospenvariation der Feuerbohne nebst allgemeinen Bemerkungen über Allogonie. *Ber. Deut. Bot. Ges.*, 33: 324-348.
A plant of *Phaseolus multiflorus* is observed showing a partial bud variation, probably caused by vegetative loss of the gene for anthocyanin formation in the flower and testa. Its offspring is recorded.
- (419) ROSÉN, D., Nagra korsningsförsök över *Anemone Hepatica* L. *Bot. Notis.*, 1915: 33-34, '15.
Some observations on the F_1 hybrids from crosses between several color varieties of *Anemone*.
- (420) SCHMIDT, J., Investigations on hops VI. On the amount of lupulin in plants raised by crossing. *Compt. Rend. Trav. Labor. Carlsberg*, 11: 165-183, '15. VII. On the flowering time of plants raised by crossing. *Ibid.*, pp. 188-198, '15.
Author dealing with crosses of cultivated varieties (♀) with Danish wild plants (♂) found that the amount of lupulin was in general intermediate in F_1 , but in some cases greater than that of the female parent. A similar behavior was also observed as to time of flowering.
- (421) STUART, W., Potato breeding and selection. *U. S. Dept. Agr. Plant Ind. Bull.*, 195: pp 35, '15.
Author found that white tuber color is not recessive in *Solanum utile* (♀) × *S. tuberosum* (♂).
- (422) TAMMES, T., Die genotypische Zusammensetzung einiger Varietäten derselben Art und ihr genetischer Zusammenhang. *Rec. Trav. Bot. Néerl.*, 12: 217-277, '15.
On the interrelation between three genes (A, B and C, see the text) in crosses with six varieties of *Linum usitatissimum*.

- (423) THOMPSTONE, E., Some observations on upper Burma Paddy (grown under irrigation). *Agr. Jour. India*, 10: 26-53, '15.
Cited by HAYES & GARBER in No. (792).

On the inheritance of pigments in glumes and seeds of the rice.

- (424) UBISCH, G. v., Analyse eines Falles von Bastardatavismus und Faktorenkoppelung bei Gerste. *Zts. Ind. Abst. u. Vererbgs.* 16: 226-237, '15.

On the production of F_1 plants with brittle rachis from several crosses between barleys with tough rachis. A partial linkage between the gene for toothiness of glumes and that for fertility is also noted.

- (425) VESTERGAARD, H. A. B., Jagttagelser vedrorende jorskellige Forkold og Egenskaber hos Brig. *Tidssk. Landb. Plant.*, 22: 336-348, '15. Rev. in *Zts. Pfl. Zucht.*, 7: 48.

Including record on crosses between *Hordeum distichum nutans* and *H. d. erectum*.

- (426) WARREN, E., A preliminary report on some breeding experiments with foxgloves. *Biometrika*, 11: 303-327, '15.

On experiments with *Digitalis gloxiniaeflora*, with reference to the inheritance of color and size of flowers.

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- (427) ALTENBURG, E., Linkage in *Primula sinensis*. *Genetics*, 1: 354-366, '16.

On the linkage between the genes for magenta flower color (R), short-style (L) and green stigma (S).

- (428) ANTHONY, R. D., and U. P. HEDRICK, Some notes on the breeding of raspberries. *New York Agr. Exp. Sta. Bull.*, 417: 75-88, '16.

Continuation of the work of WELLINGTON, No. (321). Characters investigated are: color in fruits and certain cane characters, such as glaucousness, rough and smooth bark, number of spines, dwarfishness, etc.

- (429) BATESON, W., and C. PELLEW, Note on an orderly dissimilarity in inheritance from different parts of a plant. *Proc. Roy. Soc.*, 89: 174-175, '16.

Giving a brief account on genetics of 'rogues' in *Pisum*.

- (430) BIFFEN, R. H., The suppression of characters on crossing. *Jour. Genetics*, 5: 225-228, '16.

Crosses of Rivet wheat (*Triticum turgidum*), in which its gray color and pubescence on glumes are associated in crosses with *T. vulgare*, when crossed with Polish wheat (*T. polonicum*), resulted in the total suppression of these glume characters of Rivet.

- (431) COLLINS, G. N., Correlated characters in maize breeding. *Jour. Agr. Res.*, 6: 435-453, '16.

Recording crosses (F_1 and F_2) between two maize varieties differing in endo-sperm (horny vs. waxy), branching space (long vs. short), tassel (erect vs. curved), glume (long vs. short), spikelets (in cluster vs. in pairs), leaf-sheath (with tuberculate hairs vs. without them), etc.

- (432) COLLINS, G. N., and J. H. KEMPTON, Patrogenesis. *Jour. Heredity*, 7: 106-118, '16.

The authors found that a cross *Tripsacum dactyloides* (♀) × *Euchlaena mexicana* (♂) gave plants through three generations without exhibiting any indication of the characters of the female parent, and further that these F_2 or F_3 plants crossed with maize (♂) gave offspring resembling the male parent in all characters.

- (433) CORRENS, C., Untersuchungen über Geschlechtsbestimmung bei Distelarten. *Sitzungsber. Kgl. Preuss. Akad. Wiss.*, 20: 448-477, '16. Reprinted in No. (1122).

On experiments with a dioecious species: *Cirsium arvense*, and gynodioecious plants: *C. oleraceum*, *C. acaule*, *C. palustre* and *C. Velenovskyi*.

- (434) CORRENS, C., Individuen und Individualstoffe. *Die Naturwissenschaft*, 4: 183-187, 193-198, 210-213, '16. Reprinted in No. (1122).

On the inheritance of self-sterility in *Cardamine pratensis* and *Linaria vulgaris*.

- (435) DAHLGREN, K. V. O., Eine *acaulis*-Varietät von *Primula officinalis* und ihre Erblichkeitsverhältnisse. *Svensk. Bot. Tidskr.*, 10: 530-541, '16.

On the inheritance of heterostylism and type of inflorescence (sessile umbel vs. normal) and relationship between them. The author found no *acaulis*-plants with the long style in F_2 from long-styled, normal × short styled, *acaulis*. This result is explained by assuming an elimination of gametes nb (N =normal, n =*acaulis*, B =short-style, b =long-style) in F_1 of this cross.

- (436) EAST, E. M., Studies on size inheritance in *Nicotiana*. *Genetics*, 1: 164-176, '16.

On the inheritance of corolla length in a cross between two varieties of *N. longiflora*.

- (437) EAST, E. M. Inheritance in crosses between *Nicotiana langsdorffii* and *Nicotiana alata*. *Genetics*, 1: 311-333, '16.

Recording observations through three generations on the reciprocal crosses as to the inheritance of pollen color, flower color, fertility, height of plant, rapidity of growth, and length of leaves and corollas.

- (438) EMERSON, R. A., A genetic study of plant height in *Phaseolus vulgaris*. *Nebraska Agr. Exp. Sta. Res. Bull.*, 7: 3-75, '16.

Identifying the genes controlling inheritance of growth habit, length and number of internodes in *Phaseolus*.

- (439) FLEISCHMANN, R., Die Begrannung der Ährchenspelzen in ihrer Bedeutung beim ungarischen Landweizen. *Zts. Pfl. Zücht.*, 4: 335-346, '16.

On the inheritance of length of awns developed on the empty glumes in wheat.

- (440) FROST, H. B., Mutation in *Matthiola annua*, a mendelizing species. *Amer. Jour. Bot.*, 3: 377-383, '16.

The author finds that a variety, 'Snowflake,' throws several mutants, such as large-leaved (*gigas*), smooth-leaved, crenate-leaved, narrow-leaved, and slender types. These mutants proved heterozygously dominant to the normal type.

- (441) FUJII, K., and Y. KUWADA, On the composition of factorial formula for zygotes in the study of inheritance of seed-characters of *Zea Mays* L., with notes on seed-pigments. *Bot. Mag., Tokyo*, 30: 83-88, '16.

Discussing the effect of triple fusion of nuclei in the endosperm.

- (442) GRAHAM, R., Pollination and cross-fertilization in the Juar plant (*Andropogon sorghum*, BROT.). *Mem. Dept. Agr. India, Bot. Ser.*, 8: 201-216, '16.

On the inheritance of seed coat color and glume length in certain Indian varieties of sorghum.

- (443) HALLQVIST, C., Ein neuer Fall von Dimerie bei *Brassica Napus*. *Bot. Notis.*, 1916: 39-42, '16.

On the inheritance of leaf form in the cabbage.

- (444) HASSE-BESALL, G., *Digitalis*-Studien. I. *Zts. Ind. Abst. u. Vererbgs.*, 16: 293-314, '16.

Describing the hybrid, *D. purpurea* and *D. lutea*.

- (445) HECTOR, G., Observations on the inheritance of anthocyan pigment in paddy varieties. *Mem. Dept. Agr. India, Bot. Ser.*, 8: 89-101, '16.

On anthocyanin in leaf-sheaths, glumes apices and stigma of rice.

- (446) HERIBERT-NILSSON, N., Populationsanalysen und Erbliehkeitsversuche über die Selbststerilität, Selbstfertilität und Sterilität bei dem Roggen. *Zts. Pfl. Zücht.*, 4: 1-44, '16.

- (447) HILSON, G. R., A note on the inheritance of certain stem characters in sorghum. *Agr. Jour. India*, 11: 150-155, '16.

On the inheritance of dry vs. juicy stem of sorghum, and relation of this character with color of the midrib of the leaf.

- (448) IKENO, S., Studies on the hybrids of *Capsicum annum*. On some variegated races. *Jour. Genetics*, 6: 201-229, '16.

The author finds that the variegation of *Capsicum* is transmissible through both the maternal and paternal side, so that both variegated ♀ × green ♂ and green ♀ × variegated ♂ lead to the production of variegated offspring, but it behaves as a non-Mendelian character, showing no segregation in F₂.

- (449) IKENO, S., Notes sur les résultats de l'hybridation artificielle de quelques espèces du genre *Salix*. *Bot. Mag., Tokyo*, 30: 316-320, '16.

A preliminary account of some *Salix*-crosses. See Nos. (551) and (916).

- (450) JONES, W. N., AND M. C. RAYNER, Mendelian inheritance in varietal crosses of *Bryonia dioica*. *Jour. Genetics*, 5: 203-222, '16.

Characters studied are: bloom on the berry, number of carpels in ♀ flowers, number of vascular bundles, and habit of foliage.

- (451) KALT, B., Ein Beitrag zur Kenntnis chlorophyllloser Getreidepflanzen. *Zts. Pfl. Zücht.*, 4: 143-150, '16.

On the inheritance of white seedlings in barleys and ryes.

- (452) KLEBS, G., Über erbliche Blütenanomalien beim Tabak. *Zts. Ind. Abst. u. Vererbgs.*, 17: 53-119, '16.

On the inheritance of anomalies of tobacco-flowers.

- (453) MALINOWSKI, E., Über die durch Kreuzung hervorgerufene Vielformigkeit beim Weizen. (In Polish with German résumé). *Compt. Rend. Soc. Sci. Varsovie*, 9: 757-776, '16. Rev. in *Zts. Ind. Abst. u. Vererbgs.*, 19: 219.

Crosses are made between *Triticum dicoccum* and *T. vulgare* and between *T. turgidum* and *T. dicoccum*. Though the parents used were all long-eared, the F₂ included several new forms, such as compactum, square-head and speltoid forms.

- (454) MALINOWSKI, E., O driedziczenia niektórych cech u rzodkiewki. (With English résumé). *Compt. Rend. Soc. Sci. Varsovie*, 9: 757-776, '16. Rev. in *Bot. Cbl.*, 140: 197.

Observation on crosses between two varieties of *Raphanus sativus*. Root length was found to be governed by many cumulative genes. Root color difference was monogenic, yellow dominating over white.

- (455) MALINOWSKI, E., O występowaniu nowyok form w potomstwie mieszańców *Nicotiana atropurpurea* × *N. silvestris*. (With English résumé). *Compt. Rend. Soc. Sci. Varsovie*, 9: 827-864, '16. Rev. in *Zts. Pfl. Zücht.*, 5: 327.

In this hybrid, the pollen was entirely abortive, but the female organs were partially functionable. The F₁ plants resembled *N. atropurpurea*. In the cross, F₁ ♀ × *silvestris* ♂, the color and form of the flower were found to be strictly Mendelian, and the following

characters to be governed by genes independent from one another : length of the corolla-tube, diameter of the corolla-tube, and expansion of the upper part of the corolla-tube.

- (456) MALINOWSKI, E., i M. SACHSOWA, O driedziczenia barw i kształtów kwiatu u petunii. (With German résumé). *Compt. Rend. Soc. Sci. Varsovie*, 9: 865-894, '16. Rev. in *Zts. Pfl. Zücht.*, 5: 328.

On the inheritance of flower color and other characters in *Petunia*.

- (457) MAYER-GMELIN, H., Proefnemingen met de roode klaver. *Mededeel. Ryks. Hoogere Land-, Tuinen Boschbouw-School*: pp. 63, '16. Rev. in *Zts. Pfl. Zücht.*, 5: 329.

On the inheritance of flower color and leaf-spots in the red clover.

- (458) PEKLO, J., O některých nových míšencích pšeničných. *Zemědělský. Archiv*, 7: pp. 163, '16. Rev. in *Zts. Pfl. Zücht.*, 6: 104.

On the inheritance of endosperm texture in several wheat crosses, including some observations on vegetative segregation as to ear form.

- (459) PELLEW, C., and F.M. DURHAM, The genetic behaviour of the hybrid *Primula Kewensis* and its allies. *Jour. Genetics*, 5: 159-182, '16.

The form known as *P. Kewensis* was occasionally produced from the cross, *P. verticillata* × *P. floribunda*. These are of two kinds: one partially sterile and diploid, the other fertile and tetraploid. Genetic experiments showed that the full yellow color of *floribunda* type and of *Kewensis* is monogenically dominant to the pale cream yellow of the variety of *floribunda*, known as *isabelliana*, and also that in *Kewensis* the much mealed condition of the foliar parts is recessive to the less mealiness.

- (460) PRIDHAM, J.T., Oat breeding experiments. *Agr. Gaz. N.S. Wales*, 27: 457-461, '16. Cited by HAYES & GARBER in No. 792.

On the inheritance of straw color.

- (461) RASMUSON, H., Kreuzungsuntersuchungen bei Reben. *Zts. Ind. Abst. u. Vererbgs.*, 17: 1-52, '16.

Experiments with *Vitis vinifera*, *riparia*, *rupestris* and *berlandieri*. Characters studied are: type of stamens, variegation, autumnal coloration, fruit color, glabrousness of internodes, resistance to *Plasmopara* and *Phylloxera*, etc.

- (462) RASMUSON, H., Zur Vererbung der Blütenfarben bei *Malope trifida*. *Bot. Notis.*, 1916: 237-240, '16.

A short account on inheritance of pigment in *Malope*-flowers.

- (463) ROSÉN, D., Kreuzungsversuche. *Geum urbanum* L. ♀ × *vivale* L. ♂. *Bot. Notis.*, 1916: 163-172, '16.

Several character pairs differentiating *G. urbanum* from *G. rivale* are studied in F_1 and F_2 of this cross.

- (464) SAUNDERS, E. R., The results of further breeding experiments with *Petunia*. *Amer. Nat.*, 50: 548-553, '16.

Further experiments on inheritance of doubleness of flowers, dealing with wild plants of *P. nyctaginiflora* and two wild unnamed species.

- (465) SAUNDERS, E. R., On the relation of half-hoariness in *Matthiola* to glabrousness and full hoariness. *Jour. Genetics*, 5: 145-148, '16.

Restatement of results previously published and some new data on interrelations between five genes (C, R, H, K and J) for hoariness.

- (466) SAZYPEROW, TH., *Helianthus annuus* L. $\times$ *H. argonophyllus* A. GRAY. *Bull. Angew. Bot.*, 9: 207-244, '16. Rev. in *Zts. Pfl. Zücht.*, 4: 413.

On the inheritance of resistance to rust, *Puccinia Helianthi*, in this species-cross.

- (467) SCHELLENBERG, H. C., Die Vererbungsverhältnisse von Rassen mit gestreiften Blüten und Früchten. *Vierteljahrsschrift Naturf. Ges. Zürich*, 61: 29-30, '16.

On the pigment in the pericarp of maize.

- (468) STUCKEY, H. P., Transmission of resistance and susceptibility of blossom-end rot in tomatoes. *Georgia Agr. Exp. Sta. Bull.* 121, '16. Cited by JONES in No. (552).

- (469) SURFACE, F. M., A note on the inheritance of eye pattern in beans and its relation to type of vine. *Amer. Nat.*, 50: 577-586, '16.

Recording a cross, Old Fashioned Yellow Eye and Improved Yellow Eye.

- (470) SURFACE, F. M., Studies on oat breeding III. On the inheritance of certain glume characters in the cross *Avena fatua* $\times$ *A. sativa* var. *Kherson*. *Genetics*, 1: 252-286, '16.

Characters studied in this cross are: height of plant, type of head, color of grain, type of base of grain, awning, and pubescence on several regions of grain.

- (471) TAMMES, T. Die gegenseitige Wirkung genotypischer Faktoren. *Rec. Trav. Bot. Néerl.*, 13: 44-62, '16.

On the relationship of flower color to its size in *Linum*.

- (472) TROUARD-RIOLLE, M., Hybridation entre une crucifère sauvage et une crucifère cultivée à racine tubérisée. *Compt. Rend. Acad. Sci. Paris*, 162: 511-513, '16.

Recording F_1 and F_2 plants from reciprocal crosses, *Raphanus sativus* and *R. raphanistrum*.

- (473) TROW, A. H., On the number of nodes and their distribution along the main axis in *Senecio vulgaris* and its segregates. *Jour. Genetics*, 6: 1-63, '16.

On the genetic treatment of the habit indicated in the title.

- (474) TROW, A. H., On 'albinism' in *Senecio vulgaris* L. *Jour. Genetics*, 6: 65-74, '16.

On the inheritance of albinism in the groundsel.

- (475) TSCHERMAK, E. V., Über den gegenwärtigen Stand der Gemüsezüchtung. *Zts. Pfl. Zücht.*, 4: 65-104, '16.

Brief summary of the mode of inheritance in several vegetables with special reference to their economic characters.

- (476) UBISCH, G. V., Beitrag zu einer Faktorenanalyse von Gerste. *Zts. Ind. Abst. u. Vererbgs.*, 17: 120-152, '16.

Recording crosses involving five 2-rowed and six 6-rowed varieties of barley, as well as *Hordeum spontaneum*. Characters studied are: spike density, sterility of lateral florets, awn length, formation of hoods or awns, and toothings on the lateral nerves of the glume. Two cases of linkage are described.

- (477) VALLEAU, W. D., Inheritance of sex in the grape. *Amer. Nat.*, 50: 554-564, '16.

On relations between male, hermaphrodite and female in inheritance.

- (478) WHITE, O. E., Studies of teratological phenomena in their relation to evolution and the problems of heredity II. The nature, causes, distribution, and inheritance of fasciation with special reference to its occurrence in *Nicotiana*. *Zts. Ind. Abst. u. Vererbgs.*, 16: 49-185, '16.

On the inheritance of fasciation and calycanthemy in *N. Tabacum*.

- (479) WHITE, O. E., Inheritance studies in *Pisum*. I. Inheritance of cotyledon color. *Amer. Nat.*, 50: 530-547, '16.

On the variation and genic analysis of cotyledon color in peas.

- (480) WILSON, J. H., Further experiments in crossing potatoes. *Trans. High. Agr. Soc. Scotland*, 28: 33-55, '16. Cited by HAYES & GARBER in No. (792).

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- (481) BACKHOUSE, W. O., Note on the inheritance of 'crossability'. *Jour. Genetics*, 6: 91-94, '16.

Author found that the wheat 'Shirno' had 0.21% 'crossability' in crossing with a commercial mixture of rye, while a wheat of Chinese origin had 80% 'crossability'. The hybrid between these two wheats had a 'crossability' of 3.7% and gave in F_2 several forms of 'cross-

ability'. 'Crossability' is recessive in this case and governed by Mendelian genes.

- (482) BARKER, E., Heredity studies in the morning-glory (*Ipomoea purpurea* [L.] BROTH.). *Cornell Univ. Agr. Exp. Sta. Bull.*, 392, pp. 38. '17.

On the inheritance of seed coat color, petal shape and flower color and its pattern in *Pharbitis purpurea*.

- (483) BLAKESLEE, A. F., and B. T. AVERY, Adzuki beans and Jimson weeds. *Jour. Heredity*, 8: 125-131, '17.

Giving some Mendelian cases in these plants.

- (484) COLLINS, G. N., Hybrids of *Zea Ramosa* and *Zea tunicata*. *Jour. Agr. Res.*, 9: 383-395, '17.

Recording experiments for determination of genetic compositions of tunicate and ramosa types of maize and their relationship.

- (485) COWGILL, H. B., Report on tomato and melon breeding. *Ann. Rept. Insular Exp. Sta. Port Rico*, pp. 96-98, '17-'18. Rev. in *Bot. Abst.*, 6: 662.

- (486) EAST, E. M., AND J. B. PARK, Studies on self-sterility. I. The behavior of self-sterile plants. *Genetics*, 2: 505-609, '17.

Recording crosses between *Nicotiana Forgetiana* and *N. alata* which are self-sterile, and *N. Langsdorffii*, a self-fertile species.

- (487) EMERSON, R. A., Genetical studies of variegated pericarp in maize. *Genetics*, 2: 1-35, '17.

It is suggested that there is a series of nine* or ten multiple allelomorphs to which variegation belongs.

- (488) FREEMAN, G. F., Linked quantitative characters in wheat crosses. *Amer. Nat.*, 51: 683-689, '17.

On the connection between endosperm texture and ear density in crosses with two wheat varieties.

- (489) GATES, R. R., Vegetative segregation in a hybrid race. *Jour. Genetics*, 6: 237-253, '17.

Giving observations on reciprocal crosses, *Oenothera rubricalyx* and *Oe. biennis*. The red bud character proved to be due to two genes, giving a 15:1 ratio in F₂.

- (490) GERNERT, W. B., Aphis immunity of teosinte-corn hybrids. *Science*, N. S., 46: 390-392, '17.

- (491) GOODSPEED, T. H., and R. E. CLAUSEN, Mendelian factor differences versus reaction system contrasts in heredity. *Amer. Nat.*, 51: 31-46, 92-101, '17.

Giving description of hybrids of *Nicotiana sylvestris* crossed with various varieties of *N. tabacum*.

- (492) HAYES, H. K., Inheritance of a mosaic pericarp color of maize. *Genetics*, 2: 260-283, '17.

- (493) HERIBERT-NILSSON, N., Versuche über den Vizinismus des Roggens mit einem pflanzlichen Indikator. *Zts. Pfl. Zücht.*, 5: 89-114, '17.

Inheritance of wax-formation in rye plants is included.

- (494) HONING, J. A., Het eerste Mendel-voorbeeld bij Deli-tabak. *Mededeelingen Deli-proefstation Medan. Sumatra*, 10: 185-189, '17.—Éen sterile dwergvorm van Deli-tabak, ontstaan als bastaard. *Ibid.*: pp. 24 '17. Rev. in *Bot. Cbl.*, 141: 260.

On the inheritance of a sterile dwarf form in *Nicotiana Tabacum*.

- (495) IKENO, S., Étude génétique sur les arêtes d'une race de l'orge à six rangs. *Bot. Mag., Tokyo*, 31: 263-267, '17.

On the genes controlling inheritance of awning and awn length in *Hordeum sativum hexastichum*.

- (496) IKENO, S., Variegation in *Plantago*. *Genetics*, 2: 390-415, '17.

On the genetics of chlorophyll deficiencies in *P. major asiatica*.

- (497) JONES, D. F., Linkage in *Lycopersicum*. *Amer. Nat.*, 51: 608-621, '17.

Giving reviews of papers of previous investigators as regards Mendelian characters in the tomato, and discussing linkage relations between them.

- (498) KAJANUS, B., Über Bastardierungen zwischen *Brassica Napus* L. und *Brassica rapa* L. *Zts. Pfl. Zücht.*, 5: 265-322, '17.

Giving a full account of this cross carried up to F₃. Characters observed are: leaf color, content of dry substances in the root, pubescence, bloom, leaf-margin character, color and shape of the root, etc.

- (499) KAJANUS, B., Über die Farbenvariation der *Beta*-Rüben. *Zts. Pfl. Zücht.*, 5: 357-372, '17.

Further contribution to the inheritance of root color in *Beta*.

- (500) LEHMANN, E., Vererbungsversuche mit *Veronica syriaca* ROEM. ET SCHULTES. *Ber. Deut. Bot. Ges.*, 18: 611-619, '17.

Observations on self-sterility, flower color, and number of petals and sepals in *Veronica*.

- (501) LINDSTROM, E. W., Linkage in maize: aleurone and chlorophyll factors. *Amer. Nat.*, 51: 225-237, '17.

Giving description of one linkage group involving R, G and L genes.

- (502) LOVE, H. H., and A. C. FRASER, The inheritance of the weak awn in certain *Avena* crosses. *Amer. Nat.*, 51: 481-493, '17.

Crosses are made between weak awned (Burt) and completely awnless (Sixty Day) varieties.

- (503) LUNDBERG, FR., och A. ÅKERMANN, Jakttagelser rörande fröfärgen hos avkommen av en spontan korsning mellan tvenne former av *Phaseolus vulgaris*. *Sveriges Utsädes. Tidskr.*, 27: 115-121, '17. Rev. in *Zts. Pfl. Zücht.*, 6: 191.

Describing segregation of seed coat color among offspring of a spontaneous bean hybrid.

- (504) MACDOUGAL, D. T., Analysis of a potato hybrid, *Solanum fendleri* × *S. tuberosum* ('Salinas'). *Carn. Inst. Year-book*, 16: 98, '17.

The size of tubers of the hybrid was found to be intermediate between these two parents.

- (505) MAYER-GMELIN, H., De kruising van roode ongebaarde Spelt met fluweelkaf-Essextarwe een voorbeeld van factorenanalyse. *Cultra*, 29: 140-158, '17. Rev. in *Zts. Pfl. Zücht.*, 5: 330.

On the inheritance of grain and glume color, and pubescence on glumes in crosses of Spelt with Essex (*Triticum vulgare*), including also observations on production of *compactum*-like forms from several crosses between noncompact varieties.

- (506) MCFADDEN, E. A., Wheat-rye hybrids. *Jour. Heredity*, 8: 335-336, '17.

- (507) NILSSON-EHLE, H., Untersuchungen über Speltoidmutationen beim Weizen. *Bot. Notis.*, 1917: 305-329, '17.

Recording the appearance of a series of different speltoid mutations, and analysis of their genetic behaviors.

- (508) PARNELL, F. R., G. N. R. AYYANGAR, and K. RAMIAH, The inheritance of characters in rice. I. *Mem. Dept. Agr. India, Bot. Ser.*, 9: 75-105, '17.

On the inheritance of size of outer glumes and pigment in various parts of plant, such as inner glumes, internodes, stigmas, axils, grains, pulvinus, auricles, etc.

- (509) PELLEW, C., Types of segregation. *Jour. Genetics*, 6: 317-339, '17.

Describing a peculiar type of segregation in *Campanula carpatica* var. *pelviformis* which is caused by ovules and pollen bearing different characters.

- (510) PUNNETT, R. C., Reduplication series in sweet peas. II. *Jour. Genetics*, 6: 185-193, '17.

On the relationship between three pairs of genes for purple (vs. red) flower color, long (vs. round) pollen and erect (vs. hooded) standard.

- (511) SAUNDERS, E. R., Studies in the inheritance of doubleness in

flowers. II. *Meconopsis*, *Althaea* and *Dianthus*. *Jour. Genetics*, 6: 165-184, '17.

On the Genetics of doubleness in *M. cumbria*, *A. rosea*, *D. caryophyllus* and *D. barbatus*.

- (512) SIRKS, M. J., Stérilité, autoinconceptibilité et différenciation sexuelle physiologique. *Arch. Néerl. Sci. Exact. et Natur.*, 3: 205-234, '17.

Observations on self-impotence in *Verbascum phoenicium*. The mode of inheritance was very complex. Reciprocal crosses between self-sterile and self-fertile plants very often gave different results. The individuals could be arranged in a graded series with respect to this character.

- (513) TAKAHASHI, Y., and J. FUKUYAMA, Morphological and genetic studies on the Adzuki-bean. (In Japanese). *Hokkaido Agr. Exp. Sta. Rept.* 7: pp 181, '17.

A full account of inheritance of hair form, leaf form and color in pods, stems and seed coat.

- (514) TERAQ, H., On reversible transformability of allelomorphs. *Amer. Nat.*, 51: 690-698, '17.

On the inheritance of sterility in *Oryza sativa*. The transformation of the dominant allelomorph (fertility) to the recessive allelomorph (sterility), and *vice versa*, are frequently observed.

- (515) TISDALE, W. H., Flaxwilt: A study of the nature and inheritance of wilt disease. *Jour. Agr. Res.*, 11: 573-605, '17.

Recording crosses between a variety of flax resistant to wilt and three varieties more or less susceptible to the same.

- (516) WHITE, O. E., Inheritance of endosperm color in maize. *Amer. Jour. Bot.*, 4: 396-406, '17.

Determining the dominance of white over yellow in a cross, California gold pop maize and Caragua-maize.

- (517) WHITE, O. E., Studies of inheritance in *Pisum*. II. The present state of knowledge of heredity and variation in peas. *Proc. Amer. Phil. Soc.*, 56: 487-589, '17.

A detailed summary of previous works on the genetics of *Pisum*.

- (518) WHITE, O. E., Inheritance studies in *Pisum*. IV. Interrelation of the genetic factors of *Pisum*. *Jour. Agr. Res.*, 11: 167-190, '17.

Giving description and discussion on 35 genes in *Pisum*, their effects, and their relationship to one another in inheritance. The author's own experiments deals with 8 genes among them.

- (519) ZEDERBAUER, E., Alter und Vererbung. *Zts. Pfl. Zücht.*, 5: 257-259, '17.

Author, in crossing two varieties of peas, found some irregularities as to the inheritance of cotyledon color and seed form, which he ascribed to the influence of age of flowers used in crossing.

- (520) ZINN, J., and M. SURFACE, Studies on oat breeding. V. The F_1 and F_2 generations of a cross between a naked and a hulled oat. *Jour. Agr. Res.*, 10: 293-312, '17.

On the inheritance of several characters differentiating *Avena sativa patula* from *A. s. nuda* var. *inermis*, such as glume color, awning, hulleness, pubescence, etc.

1918.

- (521) BACKHOUSE, W.O., The inheritance of glume length in *Triticum polonicum*. A case of zygotic inhibition. *Jour. Genetics*, 7: 125-133, '18.

Recording crosses of *T. polonicum* with *T. durum*, *T. turgidum* and Rivet. Relationship of glume length to degree of felting and expression of glume color is discussed.

- (522) BALLARD, W.R., Notes on geranium breeding. *Proc. Amer. Soc. Hort. Sci.*, 15: 62-65, '18.

On the inheritance of doubleness of flowers in crosses between several varieties of *Pelargonium* is included.

- (523) BARRUS, F. M., Varietal susceptibility of beans to strains of *Colletotrichum Lindemulthianum* (SACC. & MAGN.) B. & O. *Phytopathology*, 8: 589-614, '18.

Recording inoculation experiments with a number of varieties of beans and related plants belonging to *Phaseolus*, *Vigna*, *Dolichos*, *Canavalia*, *Vicia*, *Cyamopsis*, *Cicer*, *Pisum* and *Lathyrus*.

- (524) BAUR, E., Mutationen von *Antirrhinum majus*. *Zts. Ind. Abst. u. Vererbgs.*, 19: 177-193, '18.

Giving description and discussions of the mode of appearance of various mutants in *Antirrhinum*. All of them are loss mutations, except a case involving chromatophore characters. Also observations on linkage relations are made.

- (525) BAUR, E., Über eine eigentümliche mit absoluter Koppelung zusammenhängende Dominanzstörung. *Ber. Deut. Bot. Ges.*, 36: 107-111, '19.

A case is mentioned from a cross between striped and purple strains of *Antirrhinum*.

- (526) BECKER, J., Vererbung gewisser Blütenmerkmale bei *Papaver Rhoeas*. *Zts. Pfl. Zücht.*, 6: 215-221, '18.

On the inheritance of basal markings on the petals in *Papaver*.

- (527) BLAKESLEE, A. F., and B. T. AVERY, A vegetative réversion in *Portulaca*. *Brooklyn Bot. Gard. Mem.*, 1: 18, '18.

Giving a brief account of inheritance of dwarfs, some of which carried reverting (normal) branches, in *Portulaca grandiflora*.

- (528) BREGGER, T., Linkage in maize: The C aleurone factor and waxy endosperm. *Amer. Nat.*, 52: 57-61, '18.

An additional evidence to investigations of COLLINS & KEMPTON. See No. (164).

- (529) BURKHOLDER, W. H., The production of an anthracnose-resistant white marrow bean. *Phytopathology*, 8: 353-359, '18.

Giving suggestion as to genes for resistance to two strains of anthracnose in bean.

- (530) CAPORN, A. ST. C., The inheritance of tight and loose palcae in *Avena nuda* crosses. *Jour. Genetics*, 7: 229-246, '18.

Some observations on inheritance of glume color in *Avena* are included.

- (531) CAPORN, A. ST. C., An account of an experiment to determine the heredity of early and late ripening in an oat cross. *Jour. Genetics*, 7: 247-257, '18.

Giving data from a cross of an early with a late variety. Suggestion is made that earliness is a function of three genes.

- (532) CAPORN, A. ST. C., On a case of permanent variation in the glume length of extracted parental types and the inheritance of purple color in the cross *Triticum polonicum* × *T. Eloboni*. *Jour. Genetics*, 7: 259-280, '18.

The cross is carried up to F₃.

- (533) COCKERELL, T. D. A., A new hybrid sunflower. *Torrey Bot. Club*, 18: 11-14, '18.

Giving description of the F₁ hybrid of a cross, *Helianthus annuus* × *H. petiolaris*.

- (534) CORRENS, C., Zur Kenntniss einfacher mendelnder Bastarde. *Sitzungsber. Preuss. Akad. Wiss.*, 11: 221-268, '18. Reprinted in No. (1122).

On inheritance studies of leaf-shape in *Urtica* and of chlorophyll characters in *Urtica* and *Mirabilis*.

- (535) CORRENS, C., Fortsetzung der Versuche zur experimentellen Verschiebung des Geschlechtsverhältnisses. *Sitzungsber. Preuss. Akad. Wiss.*, 50: 1175-1200, '18. Reprinted in No. (1122).

On the sex inheritance in *Merandrium*.

- (536) DAHLGREN, K. V. O., Über einige Kreuzungsversuche mit *Chelidonium majus* L., *Polemonium coeruleum* L., und *Lactuca muralis* L. *Svensk. Bot. Tidsk.*, 12: 103-110, '18.

On the inheritance of laciniation in leaf and doubleness in flower of *Chelidonium*; of flower color in *Polemonium*; of leaf color in *Lactuca*.

- (537) DAVIS, B. M., The segregation of *Oenothera brevistylis* from crosses with *Oenothera Lamarckiana*. *Genetics*, 3 : 501-533, '18.

Crossing experiments show that characters of *brevistylis* are inherited as a simple recessive unit in reciprocal crosses with *Lamarckiana*.

- (538) DRUDE, Q., Erfahrung bei Kreuzungsversuchen mit *Cucurbita pepo*. *Ber. Deut. Bot. Ges.*, 35 : 26-57, '18.

Recording results from crossing in several species of *Cucurbitaceae*, chiefly among forms of *C. pepo*.

- (539) EAST, E. M., Intercrosses between self-sterile plants. *Brooklyn Bot. Gard. Mem.*, 1 : 141-153, '18.

Giving observations on crosses between self-fertile species, *Nicotiana langsdorffii*, and two self-sterile species, *N. forgetiana* and *N. alata*. Self-sterility is a Mendelian character. The earlier conclusion given in No. (486). is corrected.

- (540) EAST, E. M., and J. B. PARK, Studies on self-sterility II. Pollen tube growth. *Genetics*, 3 : 353-366, '18.

Giving an account of the phenomenon of self-sterility in *Nicotiana*. The authors suggest that differences in the rate of pollen germination are largely responsible for the differences in the length of pollen tubes from compatible and incompatible pollinations. When self-sterile plants are self-pollinated the pollen grains germinate but the pollen tubes grow so tardily that abscission of the flower occurs before the pollen tube reaches the ovary.

- (541) EMERSON, R. A., A fifth pair of factors, Aa, for aleurone color in maize and its relation to the Cc and Rr pairs. *New York Cornell Univ. Agr. Exp. Stat. Mem.*, 16 : 231-289, '18.

On the analysis of F₃ progenies derived from crosses of the colored by the colorless varieties. Effect on aleurone layer color of degree on maturity and of certain characters of underlying endosperm are discussed. Also some observations on mottled and parti-colored seeds are made.

- (542) FREEMAN, G. F., The heredity of quantitative characters in wheat. *Genetics*, 3 : 1-93, '18.

References are made to the quantitative inheritance in plants. The wheat characters studied in this paper are : the date of the appearance of the first head on each plant, the total height of the plants from the ground to the top of the tallest head, and the breadth of the leaf.

- (543) FREEMAN, G. F., Producing bread-making wheats for warm climates. *Jour. Heredity*, 9 : 211-226, '18.

Inheritance of endosperm texture is studied through four generations of crosses between white macaroni wheat, soft red bread wheat and soft white wheat. Also some observations are made on 'Yellow berry'

in which opaque spots are shown with definite margin, probably an inherited character.

- (544) GAINES, E. F., Comparative smut resistance of Washington wheats. *Jour. Amer. Soc. Agron.*, 10: 218-222, '18.

- (545) HALSTED, B. D., Colors in vegetable fruits. *Jour. Heredity*, 9: 18-23, '18.

On the color inheritance in fruit of tomatoes, egg-plants and peppers.

- (546) HALSTED, B. D., Reciprocal breeding in tomatoes. *Jour. Heredity*, 9: 169-173, '18.

Recording crosses between two widely differing varieties of tomato (i.e. 'Yellow Cherry' and 'Dandy dwarf'). Stature, color and texture of foliage, and color of fruit are suggested Mendelian. Also data are presented on the relation of weight, length and width of the fruit to type of plant, color of foliage, type of foliage and color of fruit.

- (547) HARLAND, S. C., On the genetics of crinkled dwarf rogues in Sea Island cotton. *West India, Bull.*, 16: 353-355, '18.

A further report on crosses of normal cotton by a crinkled dwarf 'rogue.' Normal type proves to be a simple dominant to the latter.

- (548) HARLAND, S. C., Tomato breeding in St. Vincent. *Agr. News Barbados*, 17: 4-5, '18.

On segregation concerning fruit characters, habit of plant, immunity to disease in a cross between two varieties of tomatoes.

- (549) HARLAND, S. C., A note on the inheritance of anthocyanin pigmentation in castor bean crosses. *Agr. News Barbados*, 17: 403, '18.

Some observations are made on crosses of a semi-wild type of castor bean by an ornamental variety known as *Ricinus Gibsoni*.

- (550) HERIBERT-NILSSON, N., Experimentelle Studien über Variabilität, Spaltung, Artbildung und Evolution in der Gattung *Salix*. *Lund Univ. Årsskr.* N.F., Avd. 2, 14: p 145, '18.

Recording a number of species crosses of *Salix*, chiefly on the hybrid, *S. viminalis* × *S. caprea*. Several characters proved to be Mendelian (see the text).

- (551) IKENO, S., On hybridisation of some species of *Salix*. *Jour. Genetics*, 8: 33-58, '18.

On the inheritance of several characters in crosses between different species of willow (*S. purpurea multinervis*, *S. gracilistyla*, etc.) (see the text).

- (552) JONES, D. F., Segregation of susceptibility of parasitism in maize. *Amer. Jour. Bot.*, 5: 295-300, '18.

On the inheritance (F₁) of susceptibility to corn smut and an unidentified leaf blight.

- (553) JONES, L. R., Disease resistance in cabbage. *Proc. Nat. Acad. Sci.*, 4: 42-46, '18.

Recording crosses of highly susceptible (to 'yellows') with resistant strains of cabbage.

- (554) KAJANUS, B., Kreuzungsstudien an Winterweizen. *Bot. Notis.*, 1918: 235-244, '18.

Recording a series of crosses between several species and varieties of *Triticum*. The following characters are briefly studied: density of spike, length of internodes, pubescence and color of glumes, awning, form and keeling of glumes, number and color of grains, texture of stem and color of auricles.

- (555) KAJANUS, B., Ueber eine Kreuzung zwischen zwei Typen von Sommerweizen. *Bot. Notis.*, 1918: 245-247, '18.

Recording crosses between two varieties of *Triticum vulgare*, with reference to the inheritance of awning and auricle color.

- (556) KEARNEY, T. H. and W. G. WELLS, A study of hybrids in Egyptian cotton. *Amer. Nat.*, 52: 491-506, '18.

Studies made on shape or size of certain organs (e.g. length of internodes, leaves, floral parts, fiber, etc.) in crosses between two varieties, Pima and Gila. No dominance or recessiveness was observed.

- (557) KEZER, A., and B. BOYACK, Mendelian inheritance in wheat and barley crosses, with probable error studies on class frequencies. *Colorado Agr. Exp. Sta. Bull.*, 249: 1-139, '18.

On the inheritance of chaff color, awning, pubescence and other characters in wheat; hoodedness, chaff color and sterility in barley.

- (558) KIESSLING, L., Über eine Mutation in einer reinen Linie von *Hordeum distichum* L. *Zts. Ind. Abst. u. Vererbgs.*, 19: 145-159, '18.

Describing of a single recessive mutant form which differs from the parental type in a reduction of chlorophyll and several other characters.

- (559) KIESSLING, L., Einige besondere Fälle von Chlorophylldefekten Gersten. *Zts. Ind. Abst. u. Vererbgs.*, 19: 160-176, '18.

Reporting the appearance of striped-leaved and white-leaved plants from crosses between two green plants of *Hordeum distichum mutans*. They are analyzed in detail. Also describing several other cases of chlorophyll defects in barley.

- (560) LEHMANN, F., Über reziproke Bastarde zwischen *Epilobium roseum* and *parviflorum*. *Zts. Ind. Abst. u. Vererbgs.*, 10: 497-511, '18.

Giving description of widely differing hybrids obtained from reciprocal crosses between the two *Epilobium* species.

- (561) LINDSTROM, E. W., Chlorophyll inheritance in maize. *New York Cornell Univ. Agr. Exp. Sta., Mem.*, 13: 3-68, '18.

Description and analysis of several chlorophyll characters in maize, i.e., 'golden,' 'japonica,' 'green-striped' and 'fine-striped' forms.

- (562) LLOYD, F. E., The origination of ascidia under quasi-experimental conditions. *Trans. Roy. Soc. Canada*, 1: 71-80, '18.

On the inheritance of fasciation in 'cluster' varieties of cotton,

- (563) LOVE, H. H., and W. T. CRAIG, The relation between color and other characters in certain *Avena*-crosses. *Amer. Nat.*, 52: 369-383, '18.

Recording crosses between *Avena fatua* and a variety of *A. sativa* (Sixty Day), with reference to relationship of glume color to production of awns and pubescence.

- (564) LOVE, H. H., and W. T. CRAIG, Small grain investigations. *Jour. Heredity*, 9: 67-76, '18.

Chiefly inheritance studies with *Avena* (glume color, pubescence, awning, hulllessness and ligulelessness, some of the genes indicating linkage) and wheat (grain color). Also description of two successful wheat-rye hybrids.

- (565) MALINOWSKI, E., Etudes sur les hybrides du froment. (In Polish and French). *Trav. d. la Soc. d. Sci. d. Varsavie*, 30: 1-320, '18. Rev. in *Zts. Pfl. Zücht.*, 8: 432.

Recording crosses of lax, squarehead and compact types of *Triticum vulgare*, with lax, squarehead and semicompact type of *T. dicoccum*, with reference to the inheritance of size and shape of glumes and spikelets, partial and complete sterility, toothing of side nerves in glumes, and length of rachis-internodes.

- (566) MANDEKIĆ, V., Nesljectivonje nikih divjstore koet kukuruza. *Gospodarska smotra*: 5-8, '18. Rev. in *Zts. Pfl. Zücht.*, 7: 40.

On the inheritance of ear-length, ear-width, row-number and other ear characters in maize.

- (567) MEUNISSIER, A., Experiences génétiques faites à Verrières. *Bull. Soc. Nat. Acclimat.*: 1-31, '18.

Summary of the results of genetical studies worked at Verriers since 1815, especially in 1902, concerning many crop plants, such as peas, wheats, oats, barleys, beets, cabbages, turnips, beans, onions and potatoes, and other ornamental and medical plants.

- (568) MIYAZAWA, B., Inheritance of leaf- and flower-color in the Japanese morning glory. (In Japanese). *Nôgaku-Kwaihō (Jour. Sci. Agr. Soc.)*, 190: 603-638, '18.

- (569) MIYAZAWA, B., Studies of inheritance in the Japanese *Convolvulus*. *Jour. Genetics*, 8: 58-82, '18.

On the relationship of leaf- to flower-color in *Pharbitis Nil*.

- (570) NESS, H., Hybrids of the live oak and overcup oak. *Jour. Heredity*, 9: 263-268, '18.

Giving description of the hybrid, *Quercus virginiana* × *Q. lyrata*. The latter type of tree is dominant. Leaves are very uniform but intermediate in size and somewhat in shape, with the *lyrata* type slightly pronounced. The former dominates in fruit except in size, which is intermediate. Bark resembles that of *lyrata*.

- (571) NEETHLING, J. H., A preliminary note on dwarfs appearing in Gluyas Early (wheat) hybrids. *South African Jour. Sci.*, 14: 540-547, '18. Rev. in *Bot. Abst.*, 3: 326.

Certain crosses of this wheat with other common wheat produced a number of dwarf forms in F_2 and F_3 .

- (572) NOHARA, S., Genetic studies of some characters in *Pisum*. *Bot. Mag., Tokyo*, 32: 91-102, '18.

On the production of hard inedible pods from a cross between two soft edible varieties.

- (573) PELTIER, G. L., Susceptibility and resistance to citrus-canker of the wild relatives, citrus fruits and hybrids of the genus *Citrus*. *Jour. Agr. Res.*, 14: 337-358, '18.

Citrus-canker is caused by *Pseudomonas citri* HASSE. The cross of susceptible × susceptible gives the hybrid showing some susceptibility. Hybrids from susceptible × resistant retain to a great extent resistance of the resistant parent.

- (574) PRIDHAM, J. T., Oat and barley breeding, agricultural research in Australia. *Advisory Council Sci. and Ind. Commonwealth of Australia, Bull.*, 7: 22-38, '18. Rev. in *Bot. Abst.*, 5: 212.

Observations on segregation of a number of characters in crosses between many varieties of oats. Also record of certain crosses with barley.

- (575) PUNNETT, R. C., Note on the origin of a mutation in the sweet pea. *Jour. Genetics*, 8: 30, '18.

On history of the 'cretin' type of flower.

- (576) RASMUSON, H., Zur Genetik der Blütenfarben von *Tropaeolum majus*. *Bot. Notis.*, 1918: 253-259, '18.

Recording certain crosses between color varieties of *Tropaeolum*.

- (577) RASMUSON, H., Über die *Petunia*-Kreuzung. *Bot. Notis.*, 1918: 287-294, '18.

On the inheritance of flower- and anther-color in *Petunia hybrida* (crossing product of *P. nyctaginiflora* × *P. violacea*).

- (578) RAYNER, M. C., Notes on the genetics of *Teucrium scorodonia crispum* (STANFIELD). *Jour. Genetics*, 7: 183-186, '18.

The author notes that the normal leaf-form of the type species is dominant to the crested form of the variety. In F_2 89 seedlings were obtained, all of which showed no trace of the 'crested' habit.

- (579) RICHARDSON, C.W., A further note on the genetics of *Fragaria*. *Jour. Genetics*, 7: 167-170, '18.

On the inheritance of growth habit, flower color, doubleness of flower, variegation, fruit flavor, etc.

- (580) SAUNDERS, E. R., On the occurrence, behaviour, and origin of a smooth-stemmed form of the common foxglove (*Digitalis purpurea*). *Jour. Genetics*, 7: 215-228, '18.

Suggestion is made that the glabrous form (dominant) may be the earlier form and the pubescent type (recessive) the derivative.

- (581) SAX, K., The inheritance of doubleness in *Chelidonium majus*, LINN. *Genetics*, 3: 300-307, '18.

Suggestion is made that doubleness in *Chelidonium* is a simple recessive.

- (582) SHAW, J. K., and J. B. NORTON, The inheritance of seed coat color in garden beans. *Massachusetts Agr. Exp. Sta., Bull.* 185: 58-104, '18.

Full account bearing on the subject, working with a number of varieties.

- (583) SHULL, G. H., The duplication of a leaf-lobe factor in the shepherd's purse. *Brooklyn Bot. Gard. Mem.*, 1: 427-443, '18.

Several varieties of *Capsella bursa-pastoris* from many parts of the world are genetically analyzed, with respect to extension of leaf lobing to midrib. Some biotypes are monomeric, while others are dimeric for this character.

- (584) Sô, M., and Y. IMAI, On the xenia in the barley. *Bot. Mag., Tokyo*, 32: 205-214, '18.

Authors find that the grain color in several crosses between blue and whitish yellow is transmitted in xenia, representing the simple dominance of blueness.

- (585) STAKEMAN, E. C., H. P. JOHN, and F. J. PIEMEISEL, Can biologic forms of stem-rust on wheat change rapidly enough to interfere with breeding for rust resistance? *Jour. Agr. Res.*, 14: 111-123, '18.

References to resistance to rust in wheat are made.

- (586) STOUT, A. B., Duplication and cohesion in the main axis in *Cichorium Intybus*. *Brooklyn Bot. Gard. Mem.*, 1: 480-485, '18.

Describing special type of fasciation of axis in *Cichorium*. The author finds that this character is strongly heritable and behaves as an incomplete dominant in F_1 of crosses with normal.

- (587) STOUT, A. B., Fertility in *Cichorium Intybus*: Self-compatibility and self-incompatibility among the offspring of self-fertile lines of descent. *Jour. Genetics*, 7: 71-103, '18.

The author finds that sterility is due to physiological incompatibilities, not to anatomical incompatibilities, and concludes that self-incompatibility and self-compatibility in chicory are not to be described as paired allelomorphs.

- (588) SUTTON, I., Report on tests of self-fertility in plums, cherriers and apples at the John Innes Horticultural Institution. *Jour. Genetics*, 7: 281-300, '18.

On horticultural and genetic treatment of self-sterility.

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- (611) COLLINS, J. L., Chimeras in corn hybrids. *Jour. Heredity*, 10: 2-10, '19.
- Description of a grain of dent corn, in which one-half is white and the other half dark purple in color. Its origin and progeny are recorded.
- (612) CORRENS, C., Vererbungsversuche mit buntblättrigen Sippen. I. *Capsella bursa-pastoris albovariabilis* und *chlorina*. *Sitzungsber. Preuss. Akad. Wiss.*, 34: 585-610, '19. Reprinted in No. (1122).

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- (622) FREEMAN, G. F., Heredity of quantitative characters in wheat. *Genetics*, 4: 1-93, '19.

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- (632) JARAMILLO, P. J., and F. J. CHITTENDEN, On double stocks. *Jour. Roy. Hort. Soc.*, **44**: 74-82, '19.
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- (633) JOHNSON, J., Inheritance of branching habit in tobacco. *Genetics*, **4**: 307-340, '19.
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- (634) JONES, D. F., Selection of pseudo-starchy endosperm in maize. *Genetics*, **4**: 307-340, '19.
On the genetic analysis of the so-called 'pseudo-starchy' endosperm, an intermediate condition between true starchy and sweet.
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- (640) KEMPTON, J. H., Inheritance of waxy endosperm in maize. *U. S. Dept. Agr. Bull.*, **754**: 1-9, '19.
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- (641) KEMPTON, J. H., Inheritance of spotted aleurone color in hybrids of Chinese maize. *Genetics*, 4: 261-274, '19.

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- (642) LEHMANN, E., Über die Selbststerilität von *Veronica syriaca*. *Zts. Ind. Abst. u. Vererbgs.*, 21: 1-47, '19.

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- (643) LEHMANN, E., Die Pentasepalie in der Gattung *Veronica* und die Vererbungsweise der Pentasepalen Zwischenrassen. *Ber. Deut. Bot. Ges.*, 36: 28-46, '19.

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- (644) LEHMANN, E., Weitere *Epilobium* Kreuzungen. *Ber. Deut. Bot. Ges.*, 37: 347-358, '19.

- (645) LINDHARD, E., und K. IVERSEN, Vererbung von roten und gelben Farbenmerkmalen bei Beta-Rüben. *Zts. Pfl. Zücht.*, 7: 1-18, '19.

On the genes for color of beet; also a case of linkage.

- (646) LOVE, H. H., and W. T. CRAIG, The synthetic production of wild wheat forms. *Jour. Heredity*, 10: 51-64, '19.

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- (647) LOVE, H. H., and W. T. CRAIG, Fertile wheat-rye hybrids. *Jour. Heredity*, 10: 194-207, '19.

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- (650) MIYAKE, K., and Y. IMAI, On the inheritance of flower color and other characters in *Digitalis purpurea*. (In Japanese). *Bot. Mag., Tokyo*, 33: 175-186, '19.

On the inheritance of stem hairing, color of flower and stem.

- (651) PELLEW, C., The genetics of *Campanula carpatica*. *Gard. Chron.*, **66**: 238, '19.

Giving a brief account of segregation of flower color, in connection with sex in *Campanula*.

- (652) RAGIONIÉRI, A., Improvement of *Richardia*. *Gard. Chron.*, **66**: 252-253, '19.

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- (653) RASMUSON, H., Genetische Untersuchungen in der Gattung *Godetia*. *Ber. Deut. Bot. Ges.*, **37**: 399-403, '19.

On the inheritance of color, size and form of flowers and habit of growth in *G. Whitneyi*; and of spot pattern on the petals and doubling of flowers in *G. amoena*.

- (654) RASMUSON, H., Zur Frage von der Entstehungsweise der roten Zuckerrüben. *Bot. Not.*, **1919**: 169-180, '19.

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- (655) SCHIEMANN, E., Zur Frage der Brüchigkeit der Gerste—ein Berichtigung. *Zts. Ind. Abst. u. Vererbgsst.*, **21**: 53, '19.

- (656) SHULL, G. H., Sterility and self- and cross-incompatibility in shepherd's purse. *Science*, N. S., **49**: 549, '19.

Giving suggestion as to the genes for sterility in *Capsella*.

- (657) SÔ, M., and T. NISHIMURA, Linkage in the Japanese morning glory. (In Japanese). *Nôgaku-Kwaihô (Jour. Sci. Agr. Soc.)*, **208**: 1088-1092, '19.

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- (658) STUCKEY, H. P., Work with *Vitis rotundifolia*, a species of Muscadine grapes. *Georgia Agr. Exp. Sta. Bull.*, **133**: 60-74, '19. Rev. in *Bot. Abst.*, **5**: 220.

On the inheritance of fruit color in connection with tendril color.

- (659) THOMPSON, W. P., The inheritance of earliness and lateness in wheat. *Proc. and Trans. Roy. Soc. Canada*, **3**: 143-162, '19.

Observations on the subject in several crosses through three generations.

- (660) TJEBS, K., en H. N. KOOIMAN, Erfelijkhedsonderzoekingen bij boonen. *Genetica*, **1**: 323-346, '19.

Giving suggestion as to the genes for seed coat color in beans.

- (661) TJEBS, K., en H. N. KOOIMAN, Erfelijkhedsonderzoekingen bij boonen. III. Albinisme. *Genetica*, **1**: 532-538, '19.

Recording some experiments with an albino-throwing strain of bean.

- (662) TSCHERMAK, E. v., Bastardierungsversuche mit der grün-

samigen Chevrier-Bohne. *Zts. Pfl. Zücht.*, 7: 57-61, '19.

Suggestion is made that yellow-seeded beans differ from the green-seeded by a single gene yellow being dominant, also a correlation between green seed coat and green pods is mentioned.

- (663) UBISCH, G. v., II. Beitrag zu einer Faktorenanalyse von Gerste. *Zts. Ind. Abst. u. Vererbgs.*, 20: 65-117, '19.

Giving a full account of barley cross experiments to analyze the following characters: brittleness of rachis, length of rachis internodes, sterility of lateral florets, awn length, hoods, culm length, hullness of grain, grain color and type of basal bristle.

- (664) UBISCH, G. v., Gerstenkreuzungen. *Landw. Jahrb.*, 53: 191-244, '19. Rev. in *Zts. Pfl. Zücht.*, 7: 141.

On the inheritance of basal bristle, dentation of lower glume, thickness of ear, number of rows in head, abnormalities and other quantitative characters in barley.

- (665) VESTERGAARD, H. A. B., Jagttagelser vedsprande Arvelighedsforhold hos Lupin, Heveda og Byg. *Tidskr. f. Planteavl.*, 26: 491-510, '19. Rev. in *Exp. Sta. Rec.*, 42: 133.

On the inheritance studies with *Lupinus angustifolius* (flower color), barley (an abnormal type) and wheat (speltoid mutation).

- (666) VRIES, E. DE, Versuche über die Frucht- und Samenbildung bei Artkreuzungen in der Gattung *Primula*. *Rec. Trav. Bot. Néerl.*, 16: 63-205, '19.

The work deals with several *Primula* species, such as *P. Auricula*, *P. acaulis*, *P. Sibthorpii*, *P. elatior*, *P. Juliae* and *P. hirsuta*, concerning seed and fruit formation in several species crosses in connection with heterostylism.

- (667) WARBURTON, C. W., The occurrence of dwarfness in oats. *Jour. Amer. Soc. Agron.*, 11: 72-76, '19.

Describing dwarfs observed in Victory oats and its inheritance.

- (668) WARREN, E., The pure line hypothesis and the inheritance of small variations. *South African Jour. Sci.*, 15: 535-567, '19. Rev. in *Bot. Abst.*, 3: 334.

Recording a species cross, *Tropaeolum majus* × *T. minus*.

- (669) WINGE, Ö., On the non-Mendelian inheritance in variegated plants. *Compt. Rend. Trav. Lab. Carlsberg*, 143: 1-20, '19.

Giving the results of experiments with normal green and albomaculata varieties of *Humulus japonicus*.

- (670) WITTE, H., Über weibliche Sterilität beim Timotheegras (*Phloem pratense* L.) und ihre Erbllichkeit. *Svensk. Bot. Tidsk.*, 13: 32-42, '19.

Suggestion is made that female sterility in this plant is a simple recessive character.

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- (671) ÅKERMAN, Å., Speltlike bud-sports in common wheat. *Hereditas*, 1 : 116-127, '20.

Giving descriptions of several chimera-spikes, conditioned by a speltoid heterozygote and its corresponding normal type.

- (672) AUCHTER, E. C., A preliminary report on apple and pear breeding in Maryland. *Proc. Amer. Soc. Hort. Sci.*, 17 : 19-32, '20.

Including inheritance study on several fruit characters of apple, such as form, size, color, flavor and season.

- (673) BACH, S., Zweierlei Weisslinge bei Mais. *Zts. Pfl. Zücht.*, 7 : 238-241, '20.

Describing two types of albino in maize and the mode of their inheritance.

- (674) BATESON, W., Genetic segregation. *Proc. Roy. Soc. B.*, 91 : 358-368, '20.

Giving a general discussion on segregation. Protesting the general application of MORGAN's theory, citing several cases discordant with it. As an example genetics of a dwarf *Campanula* is described.

- (675) BATESON, W., and C. PELLEW, The genetics of 'rogue' among culinary peas (*Pisum sativum*). *Proc. Roy. Soc. B.*, 91 : 186-195, '20.

Giving a summary of previous results together with details of further experiments on this subject.

- (676) BLAKESLEE, A. F., A dwarf mutation in *Portulaca* showing vegetative reversions. *Genetics*, 5 : 419-433, '20.

Further record on inheritance on dwarf *Portulaca*. See No. (527).

- (677) BLAKESLEE, A. F., J. BELLING and M. E. FARNHAM, Chromosomal duplication and Mendelian phenomena in *Datura* mutants. *Science*, N. S., 52 : 388, '20.

It was found that in the tetraploid *Daturas* the zygote **AAaa** (A being the gene for purple flowers) gave purple and white offspring in a ratio of 35:1, instead of the ordinary 3:1 ratio.

- (678) BLARINGHEM, L., Stabilité et fertilité de l'hybride *Geum urbanum* × *G. rivale* L. *Compt. Rend. Acad. Sci.*, 170 : 1284-1286, '20.

Recording non-appearance of segregation in F_2 of the cross.

- (679) BLARINGHEM, L., Hérité et nature de la pelorie de *Digitalis purpurea* L. *Compt. Rend. Acad. Sci.*, 171 : 252-254, '20.

The author states that the axial peloria of this species is an extreme form of fasciation. Crosses between a plant with peloria and a wild *Digitalis* without it are made.

- (680) COLLINS, G. N., Waxy maize from Upper Burma. *Science*, N. S., 52: 48-51, '20.

Describing plants grown from the Burma waxy seeds which are very different from those raised from the ordinary Chinese waxy seeds, though the endosperm texture proved to be genetically identical.

- (681) COLLINS, G. N., and J. H. KEMPTON, Heritable character of maize. I. Lineate leaves. *Jour. Heredity*, 11: 3-6, '20.

The authors point out that it is desirable to report characters of genetic value in maize in order to avoid needless duplication of the workers in the field. This paper deals with a new recessive chlorophyll disorder.

- (682) COLLINS, G. N. and J. H. KEMPTON, A teosinte-maize hybrid. *Jour. Agr. Res.*, 19: 1-38, '20.

On a number of character pairs in F_2 of Florida teosinte ♀ × Tom Thumb pop corn ♀.

- (683) CONNERS, C. H., Some notes on the inheritance of unit characters in the peach. *Proc. Amer. Soc. Hort. Sci.*, 16: 24-36, '20.

Recording crosses between large-, medium-, and small-blossomed varieties of peach, and also some observations on fruit color, date of ripening and freestone vs. clingstone.

- (684) CORRENS, C., Vererbungsversuche mit buntblättrigen Sippen. III. *Veronica gentianoides albocincta*. IV. Die *albomarmorata*- und *albopulverea*-Sippen. V. *Mercurialis annua versicolor* und *xantha*. *Sitzungsber. d. Preuss. Acad. Wiss.*, 6: 212-240, '20. Reprinted in No. (1122).

On the genic analysis of chlorophyll variations in *Veronica*, *Ipomaea*, *Tropaeolum* and *Mercurialis*.

- (685) COULTER, M. C., Inheritance of aleurone colour in maize. *Bot. Gaz.*, 69: 407-425, '20.

Crosses involving **Rr**, **Cc** and **Pp** are made to determine their effects on the color of aleurone layer.

- (686) CRANDALL, C. S., The apple cross—Tolman × Malus Toringo. *Proc. Amer. Soc. Hort. Sci.*, 16: 60-66, '20.

Crosses between Tolman, a standard variety of apple and a dwarf form of Malus Toringo gave F_1 seedlings of intermediate form, but more nearly approaching the dwarf form.

- (687) CRANDALL, C. S., Observations on characters of forms of Malus. *Proc. Amer. Soc. Hort. Sci.*, 16: 131-135, '20.

Brief account of crosses involving differences in size of leaf and fruit. There was a preponderance in F_1 of large forms.

- (688) EAST, E. M., and D. F. JONES, Genetic studies on the protein content in maize. *Genetics*, 5: 543-610, '20.

Presenting a comparison between self- and open-pollinated ears, with respect to percentage of protein

- (689) EMERSON, R. A., Heritable characters of maize. III. Pistillate flowered maize plants. *Jour. Heredity*, 11: 65-76, '20.

Giving descriptions of two types of pistillate flowered maize plants called under the names 'tassel seed' and 'tassel ear' and their modes of inheritance.

- (690) ENGLENDOW, F. L., Inheritance in barley. I. The lateral florets and the rachilla. *Jour. Genetics*, 10: 93-108, '20.

Recording Mendelian segregation in F_2 of crosses between smooth and bristly rachillae. Also suggestion is made that several forms of lateral floret constitute a system of multiple allelomorphs.

- (691) ENGLENDOW, F. L., The inheritance of glume-length and grain-length in wheat cross. *Jour. Genetics*, 10: 109-134, '20.

A cross of Polish (*Triticum polonicum*) with Kubanka (a variety of *T. durum*) is investigated with respect to the length of glumes and grains. The nature of 'shift' occurring in F_2 is discussed. The author concludes from his experiments that grain length is a maternal character in spite of the demands of 'double fertilization' theory. Also some observations on inheritance of hollow and solid straws are made.

- (692) EYSTER, W. H., Heritable characters of maize. VI. Zigzag culms. *Jour. Heredity*, 11: 349-357, '20.

Giving a description of a new double recessive character in maize.

- (693) FRIMMEL, FR., Über einen Versuch der Züchtung schwarzer Farbentöne an der Gartenprimel. *Zts. Pfl. Zücht.*, 7: 346-356, '20.

An attempt is made to secure black primulas by crossing suitable varieties.

- (694) FRUWIRTH, C., Neunzehn Jahre Geschichte einer reinen Linie der Futtererbse. *Fühlings Landw. Zts.*, 69: 1-28, '20. Rev. in *Bot. Abst.*, 6: 199.

On spontaneous variations that occurred in a pure line of field pea. Flower-, seed-color and several chlorophyll defects are analyzed.

- (695) GAINES, E. F., The inheritance of resistance to bunt or stinking smut of wheat. *Jour. Amer. Soc. Agr.*, 12: 124-132, '20.

Many wheat varieties are tested for bunt resistance. Multiple genes are postulated for this character.

- (696) HAGIWARA, T., On the coupling of the leaf characters in the Japanese morning glory. (In Japanese). *Bot. Mag., Tokyo*, 34: 17-18, '20.

Recording the coupling between rolledness and variegation of the leaf in *Pharbitis Nil*.

- (697) HARLAN, H. V., and H. K. HAYES, Occurrence of the fixed intermediate, *Hordeum intermedium Haxtoni*, in crosses between *H. vulgare pallidum* and *H. distichon palmella*. *Jour. Agr. Res.*, 19: 575-591, '20.

Observations given on F_1 , F_2 and F_3 from the crossing of 6-rowed Manchuria with 2-rowed Svanhals variety.

- (698) HARLAND, S. C., Inheritance of certain characters in the cow-pea (*Vigna sinensis*) II. *Jour. Genetics*, 10: 193-205, '20.

Characters studied are: stem-, pod- and flower-color, seed coat pattern and its color. Some cases of linkage are also noted.

- (699) HARLAND, S. C., Inheritance in *Ricinus communis* L. Part I. *Jour. Genetics*, 10: 207-218, '20.

Characters studied are: blooming, spining of the capsule and color of the vegetative parts. A case of linkage is noted.

- (700) HARLAND, S. C., Inheritance of *Dolichos lablab* L. I. *Jour. Genetics*, 10: 219-226, '20.

Brief accounts given on the analysis of growth habit, color of flower, seed, nodes and leaf-ribs.

- (701) HARLAND, S. C., Studies of inheritance in cotton. I. The inheritance of corolla colour. *West. Ind. Bull.*, 18: 13-19, '20.

Recording crosses of some of the 'native' cottons with Upland and with Sea Island, with respect to the inheritance of several grades of yellow flower colors.

- (702) HARPER, R. A., Inheritance of sugar and starch characters in corn. *Torrey. Bot. Club. Bull.*, 47: 137-186, '20.

Crosses between sweet and starchy varieties are carried to F_4 . Criticizing the current theory based on the Mendelism on this subject.

- (703) HAYES, H. K., and H. V. HARLAN, The inheritance of the length of internode in the rachis of the barley spike. *U.S. Dept. Agr. Bull.*, 869: 1-26, '20.

Four dense and six lax or semi-lax varieties are used for genic analysis of spike density.

- (704) HAYES, H. K., J. H. PARKER and C. KURTZWEL, Genetics of rust resistance in crosses of varieties of *Triticum vulgare* with varieties of *Tr. durum* and *Tr. dicoccum*. *Jour. Agr. Res.*, 19: 532-542, '20.

On the inheritance of a resistance to a pure strain of *Puccinia graminis tritici* in connection with certain morphological characters.

- (705) HERIBERT-NILSSON, N., Zuwachsgeschwindigkeit der Pollenschläuche und gestörte Mendelzahlen bei *Oenothera Lamarckiana*. *Hereditas*, 1: 41-67, '20.

- Giving explanation of different results from crossing **Rr** (red-nerved) and **rr** (colorless nerved) and its reciprocals.
- (706) HERIBERT-NILSSON, N., Kritische Betrachtungen und factorielle Erklärung der *Laeta-velutina*-Spaltung bei *Oenothera*. *Hereditas*, 1: 312-342, '20.
- Critisizing DE VRIES' and RENNER's hypotheses on segregation of *Oe. laeta* ♂ × *velutina* ♀.
- (707) IKENO, S., Etudes d'hérédité sur la réversion d'une race de *Plantago major*. *Rev. Gén. Bot.*, 32: 49-56, '20.
- A preliminary report on reversion that occurred in a dwarf race of *Plantago*.
- (708) IMAI, Y., Genetic studies in morning glories. II and III. (In Japanese). *Bot. Mag., Tokyo*, 34: 54-65, 217-247, '20.
- On the inheritance of several leaf forms in *Pharbitis Nil*, and of color in *Ph. purpurea*.
- (709) JONES, D. F., Heritable characters of maize. IV. A lethal factor—defective seeds. *Jour. Heredity*, 11: 161-167, '20.
- Describing a new recessive character in maize.
- (710) JONES, L. R., J. C. WALKER, AND W. R. TISDALE, *Fusarium* resistant cabbage. *Wisconsin Agr. Exp. Sta. Bull.*, 48: 1-34, '20.
- Selection experiments showed that resistance to cabbage yellows (*Fusarium conglutinans*) is due to multiple genes.
- (711) KAPPERT, H., Über das Vorkommen vollkommener Dominanz bei einem quantitativen Merkmal. *Zts. Ind. Abst. u. Vererbgs.*, 22: 199-209, '20.
- Homozygous tall and heterozygous tall plants are compared in two varietal crosses of peas.
- (712) KELLY, J. P., A genetical study of flower form and flower color in *Phlox Drummondii*. *Genetics*, 5: 189-248, '20.
- (713) KEMPTON, J. H., Linkage between brachytic culms and pericarp and cob color in maize. *Jour. Washington Acad. Sci.*, 11: 13-20, '20.
- Reviewing earlier results on linkage in maize and giving a new case of linkage between **Br** and **P**.
- (714) KEMPTON, J. H., Heritable character in maize. III. Brachytic culms. *Jour. Heredity*, 11: 111-115, '20.
- Describing a new recessive variation, 'brachytic culms' and discussing analogous cases in other plants.
- (715) KEMPTON, J. H., Heritable characters of maize. V. Adherence. *Jour. Heredity*, 11: 116-167, '20.
- Giving a description of a new recessive character, 'adherence'.

- (716) KOOIMAN, H. N., Over de erfelijkheid van de kleur der zaadhuid van *Phaseolus vulgaris*. *Diss. Univ. Utrecht. Bussum C. A. J. v. Dishoek*. '20. Cited by SIRKS in No. (959).
- (717) LEAKE, H. M., and B. R. PERSHAD, A preliminary note on the flower colour and associated characters of the opium poppy. *Jour. Genetics*, 10: 1-20, '20.
Suggestion is made as to genes for color, shape and size of petals and color of seed.
- (718) LINDSTROM, E. W., Chlorophyll factors of maize. *Jour. Heredity*, 11: 269-277, '20.
On the relationship of chlorophyll-genes to productivity of maize.
- (719) LINGELSHEIM, A., *Polemonium coeruleum* × *reptens* (*P. Limprichtii* LINGELSH.), die erste sichergestellte Hybride der Gattung. *Oest. Bot. Zts.*, 69: 164-166, '20.
Describing the hybrid between these species, which showed characters of both parents.
- (720) LOTSY, J. P., *Cucurbita*-Strijdvragen. II. Eigen onderzoekingen. *Genetica*, 2: 1-21, '20.
On the inheritance of fruit characters in *Cucurbita maxima* and *C. pepo*.
- (721) MALINOWSKI, E., Die Sterilität der Bastarde im Licht des Mendelismus. *Zts. Ind. Abst. u. Vererbgs.*, 22: 225-235, '20.
Crosses between *Triticum vulgare* and *T. dicoccum* are made with reference to the degree of fertility of the offspring. Also criticizing BELLING's hypothesis on this subject.
- (722) MATTHEWS, J. R., Hybridism and classification in the genus *Rosa*. *New Phytologist*, 19: 153-171, '20.
Presenting an attempt to classify the genus *Rosa* on the basis of assumption of four unit characters.
- (723) MEUNISSIER, A., Observations faites à Verrières par PHILIPPE DE VILMORIN, sur le caractère 'hile noir' chez le pois. *Jour. Genetics*, 10: 53-60, '20.
Describing black eyed varieties of peas and crosses with white-eyed strains, also genetical relationship of hilum color to seed coat color.
- (724) MIYAKE, K., and Y. IMAI, On the inheritance of flower color and other characters in *Digitalis purpurea*. *Jour. Coll. Agr., Imp. Univ. Tokyo*, 6: 391-402, '20.
On the inheritance of pubescence and anthocyanin in the foxglove.
- (725) MIYAKE, K., and Y. IMAI, Genetic experiments with morning glories. I. (In Japanese). *Bot. Mag., Tokyo*, 34: 1-26, '20.
Discussing relationship between 7 pairs of genes involving leaf, flower- and seed-characters.

- (726) MIYAZAWA, B., On the inheritance in the Japanese morning glory. (In Japanese). *Nogaku-kwaihō (Jour. Sci. Agric. Soc.)*, 216: 579-635, '20.

On the inheritance of flower- and leaf-colors in *Pharbitis Nil*.

- (727) NILSSON-EHLE, H., Über Resistenz gegen *Heterodera Schachtii* bei gewissen Gerstensorten, ihre Vererbungsweise und Bedeutung für die Praxis. *Hereditas*, 1: 1-34, '20.

Describing crosses between an immune and a susceptible barley.

- (728) NILSSON-EHLE, H., Multiple Allelomorphe und Komplexmutationen beim Weizen. (Untersuchungen über Speltoidmutationen beim Weizen II). *Hereditas*, 1: 277-311, '20.

Discussing three series of multiple allelomorphs in wheat: pubescent—half-pubescent—glabrous glume; awnless—half-awned—full-awned spike; and normal type—awnless speltoid—awned speltoid. Also some theoretical consideration on nature of genes and complex mutations.

- (729) OLSON, G. A., E. G. SCHAFER, M. A. MCCALL, AND C. E. HILL, [Report of work with field crops in Washington.] *Washington Sta., Bull.*, 155: 16, 17, 26-29, 46-49, '20.

On the inheritance of various characters of wheats: resistance to rust, awning, shooting time, dwarfishness, etc.

- (730) PARKER, J. H., A preliminary study of the inheritance of rust resistance in oats. *Jour. Amer. Soc. Agr.*, 12: 23-38, '20.

Recording F_2 of a cross, Burt $\times$ Sixty Day with reference to crown or leaf rust resistance.

- (731) RAGIONIERI, A., *Brassica* crosses. *Gard. Chron.*, 68: 60, '20.

On the Mendelian analysis of bulb-formation and leaf forms in crosses between Chinese cabbage, Pe-tsai and other Brassicas.

- (732) RASMUSON, H., Über einige genetische Versuche mit *Papaver Rhoeas* und *Papaver laevigatum*. *Hereditas*, 1: 107-114, '20.

Giving a brief account on inheritance of the habit of hairy development, pigmentation of flower and latex, and chlorophyll color in *Papaver*.

- (733) RASMUSON, H., On some hybridisation experiments with varieties of *Collinsia* species. *Hereditas*, 1: 178-185, '20.

On the inheritance of flower- and stem-color in *Collinsia bicolor* and of spots on the flower and variegation in *C. tinctoria*.

- (734) RASMUSON, H., Die Hauptergebnisse von einigen genetischen Versuchen mit verschiedenen Formen von *Tropaeolum*, *Clarkia* und *Impatiens*. *Hereditas*, 1: 270-276, '20.

Giving a brief account of inheritance of leaf-, flower-color and growth habit in *Tropaeolum majus*, of flower-color in *Clarkia elegans* and *C. pulchella*, and of flower-color and height of plant in *Impatiens Balsamina*.

- (735) RASMUSON, J., Mendelnde Chlorophyll-Faktoren bei *Allium Cepa*. *Hereditas*, 1: 128-134, '20.

Recording some cases of chlorophyll segregation in self-fertilized pedigrees.

- (736) RAUM, J., Ein weiterer Versuch über die Vererbung der Samenfarbe bei Rotklee. *Zts. Pfl. Zücht.*, 7: 149-155, '20.

Giving suggestion of multiple genes for seed coat color in red clover.

- (737) RICHARDSON, C. W., Some notes on *Fragaria*. *Jour. Genetics*, 10: 39-46, '20.

On the inheritance of the following characters: flower color, double flowering, shape of foliage, variegation in foliage, fruit flavor, size of fruit, runners, sex, etc.

- (738) SALAMAN, R. N., and J. W. LESLEY, Genetic studies in potatoes. The inheritance of an abnormal haulm type. *Jour. Genetics*, 10: 21-37, '20.

Giving description of two distinct types, 'prostrate' and 'procumbent' and their genetical analysis.

- (739) SAUNDERS, E. R., Multiple allelomorphs and limiting factors in inheritance in the stock (*Matthiola incana*). *Jour. Genetics*, 10: 149-178, '20.

Describing multiple allelomorphs involving hoary, half-hoary and glabrous in *Matthiola*.

- (740) SHULL, G. H., A third duplication of genetic factors in shepherd's purse. *Science*, N. S. 51: 596, '20.

Giving a brief account of a cross, *Capsella bursa-pastoris* × *C. Heegeri*, with reference to leaf-texture.

- (741) SIRKS, M. J., De analyse van een spontane boonenhybride. *Genetica*, 2: 97-114, '20.

Giving suggestion of 7 allelogenes for seed coat color in beans.

- (742) SIRKS, M. J., Erfelijkheids en selectieonderzoekingen bij *Vicia*-sorten. I. De navelkleur van *Vicia Faba*. *Genetica*, 2: 193-199, '20.

On the genic analysis of naval colors in the English bean.

- (743) STOMPS, T. J., Über zwei Typen von Weissrandbunt bei *Oenothera biennis* L. *Zts. Ind. Abst. u. Vererbgs.*, 22: 261-274, '20.

Describing two types of white variegation characterized by vegetative mutation, one producing piebald variegation in F₁ of the cross of variegated-twigs by green ones, and the other giving green progeny in a similar cross and also selfing of both green and variegated twigs. Analogous cases in other plants are fully discussed.

- (744) STOUT, A. B., Further experimental studies on self-incompatibility in hermaphrodite plants. *Jour. Genetics*, 9: 85-129, '20.

Dealing with *Verbascum phoeniceum*, *Eschscholtzia californica*, *Nicotiana Forgetiana*, *Brassica pekinensis*, *Raphanus sativus* and *Cichorium intybus*.

- (745) SUTTON, A. W., *Brassica* crosses. *Gard. Chron.*, 67: 20, '20.

Giving a brief account of crosses between cauliflower and kohlrabi.

- (746) TEDIN, H., The inheritance of flower colour in *Pisum*. *Hereditas*, 1: 68-97, '20.

On the analysis of flower color in peas; also on relation of flower color to abnormal structure of hilum.

- (747) TROUARD-RIOLLE, Y., Les hybrides de *Raphanus*. *Rev. Gén. Bot.*, 32: 438-447, '20.

Recording hybrids between *R. raphanistrum* and varieties of *R. sativus*, with reference to flower color, structure of silique, sugar and starch content and root development. The author points out that the law of uniformity in F_1 is not absolute in these hybrids.

- (748) YASUI, K., Genetical studies in *Portulaca grandiflora*. *Bot. Mag., Tokyo*, 34: 55-65, '20.

On the genes for double flowering and flower color in *Portulaca*.

- (749) YASUI, K., Genetical studies in Japanese morning glory. I. The inheritance of albinism and purple color in the stem and leaves. *Bot. Mag., Tokyo*, 34: 141-145, '20

1921.

- (750) ÅKERMAN, Å., Undersökningar rörande flyghavrelika mutationer i vanlig odlad havre. *Sveriges Utsäd. Tidsk.*, 31: 266-268, '21. Rev. in *Internat. Rev. Sci. & Pract.*, '22: 478.

Describing and analyzing a fatuoid mutation of *Avena sativa*.

- (751) ÅKERMAN, Å., Untersuchungen über Bastarde zwischen *Epilobium hirsutum* und *Epilobium montanum*. *Hereditas*, 2: 99-112, '21.

Recording F_1 of the reciprocal cross between the two species.

- (752) ALTENBURG, E., Interference in *Primula sinensis*. *Amer. Nat.*, 55: 78-80, '21.

Giving a recalculation of the linkage data presented in a former paper No. (424).

- (753) ANDERSON, E. G., The inheritance of salmon silk color in maize. *New York Cornell Univ. Exp. Sta. Mem.*, 48: 539-554, '21.

On the origin and inheritance of salmon silk color in maize; also on the relations of this character to other genes, **B, A, R, Pl** and **Y**.

- (754) ANONYMOUS, [Vegetative investigations at the California Station.] *Calif. Exp. Sta. Rept.*, pp. 88, 89, 93, '21.

Studies on the inheritance in radish, with reference to flower-, root-color and linkage relations, conducted by H. B. FROST at the Citrus Substation.

- (755) BATESON, W., and A. E. GAIRDNER, Male-sterility in flax, subject to two types of segregation. *Jour. Genetics*, 11: 269-276, '21.

Presenting an example of peculiar inheritance called under the name of 'unilateral' segregation in which the allelomorphs are carried wholly to one sexual side, as contrasted to the normal 'ambilateral' segregation.

- (756) BLAKESLEE, A. F., A chemical method of distinguishing genetic types of yellow cones in *Rudbeckia*. *Zts. Ind. Abst. u. Vererbgs.*, 25: 211-221, '21.

Recording crosses between two types of yellow-coned plants, distinguished by treatment with alkalies.

- (757) BLARINGHEM, L., Recherches sur les hybrides du lin (*Linum usitatissimum* L.) *Compt. Rend. Acad. Sci., Paris*, 173: 329-331, '21.

Recording two allelomorphs of flax, brown vs. white seed and ciliated vs. naked septa.

- (758) BLARINGHEM, L., Sur la production de 'variétés à graines marbrées' de la Fève (*Vicia Faba* L.). *Compt. Rend. Acad. Sci., Paris*, 173: 666-668, '21.

- (759) BLARINGHEM, L., Hérité des caractères physiologique chez les hybrides d'orges. *Compt. Rend. Acad. Sci., Paris*, 173: 1396-1398, '21.

On the inheritance of hoodedness in a cross, *Hordeum nudum* × *H. trifurcatum*.

- (760) BLARINGHEM, L., Études sur les hybrides d'orges. *Ann. Sci. Agr. Franç. et Étrang.*, 38: 177-230, '21. Rev. in *Exp. Sta. Rec.* 50: 228.

On the inheritance of barley—stiff vs. downy hairs on axis of spikelet and rough vs. smooth lateral dorsal veins of the grain.

- (761) BROOKS, F. T., The inheritance of disease-resistance in plants. *Trans. British Mycol. Soc.*, 7: 71-78, '21.

The unpublished results of ARMSTRONG's work on the inheritance of resistance to yellow rust and mildew in wheat are recorded.

- (762) BROŽEK, A., Jednoduchý případ mendelovského dědění v krebse květů dvou rač *Mimulus quinquevulnerus* HORT. *Biol. Listů.*, 8: 13-33, '21., Rev. in *Zts. Pfl. Zücht.*, 9: 139.

On the inheritance of spotting of flowers in *Mimulus*.

- (763) BRYAN, W. E., and E. H. PRESSLEY, Plant breeding. *Ariz. Agr. Exp. Sta. Ann. Rept.* '20-'21, 32: 603-605, '21. Rev. in *Exp. Sta. Rec.*, 48: 433.

On the inheritance of earliness in wheat and alfalfa.

- (764) BURLINGAME, L., Variation and heredity in *Lupinus*. *Amer. Nat.*, 55: 427-448, '21.

On the inheritance of flower color in *Lupinus apricus vallicola*, *L. pipersmithii*, and *L. nanus*.

- (765) BUSHNELL, J. W., Results of selection in the Alaska-pea. *Proc. Amer. Soc. Hort. Sci.*, 18: 41-47, '21.

On the productiveness in the pea.

- (766) CHRISTIE, W., Die Vererbung gelbgestreifter Blattfarbe bei Hafer. *Zts. Ind. Abst. u. Vererbgs.*, 27: 134-141, '21.

Recording a case of non-Mendelian inheritance of a chlorophyll disorder in oat.

- (767) CLAUSEN, R. E., and T. H. GOODSPEED, Inheritance in *Nicotiana Tabacum*. II. On the existence of genetically distinct red-flowering varieties. *Amer. Nat.*, 55: 328-334, '21.

Comparing the authors' results on the inheritance of flower color in tobacco with those obtained by ALLARD. See No. (597).

- (768) COBB, F., A case of Mendelian inheritance complicated by heterogametism and mutation in *Oenothera pratincola*. *Genetics*, 6: 1-42, '21.

The present paper deals with the inheritance of *mut. formosa* which is characterized by revolute-leaves. The character behaves as a simple recessive to the flat leaf of *typica* in crosses, *mut. formosa* E $\times$ strain C (*typica*). But its reciprocals give matroclinic progeny. These results are explained by assuming that (1) *Oenothera pratincola* produces 2 types of gametes, α (usually ♀) and β (usually ♂), (2) the α gamete often mutates into α' which is characterized by a loss of a gene for flatness present in the α gamete and produces *mut. formosa*, and (3) there is also an allelogene pair, F (for flatness) and f (for revoluteness), of which the dominant allelogene is carried by strain C in both the α and β gametes. Thus: (1) Strain C ($\alpha\beta FF$) $\times$ *mut. formosa* ($\alpha'\beta ff$) $\rightarrow$ F₁, flat-leaved ($\alpha\beta FF$) $\rightarrow$ F₂, $1\alpha\beta FF$: $2\alpha\beta Ff$: $1\alpha\beta ff$, all flat-leaved by the presence of a gene for flatness in the α gamete; (2) *mut. formosa* ($\alpha'\beta ff$) $\times$ strain C ($\alpha\beta FF$) $\rightarrow$ F₁, flat-leaved ($\alpha'\beta Ff$) $\rightarrow$ F₂, $1\alpha'\beta FF$: $2\alpha'\beta Ff$: $1\alpha'\beta ff$, resulting in 3 flat: 1 revolute. These assumptions are further confirmed by F₃, F₄ and F₅ breeding tests.

- (769) COLLINS, E. J., The 'problem of the inheritance of immunity to wart disease in the potato. *Gard. Chron.*, 70: 260, '21.

Suggestion is made that susceptibility is due to a single dominant gene.

- (770) COLLINS, J. L., Reversion in composites. *Jour. Heredity*, 12: 129-133, '21.

Giving a description of a teratological form, 'palea,' of *Crepis capillaris* resulting from a cross between two different strains.

- (771) CONNERS, C. H., Inheritance of foliar glands of the peach. *Amer. Soc. Hort. Sci., Proc.*, 18: 20-26, '21.

Recording crosses between three types of leaves with respect to glands.

- (772) CORRENS, C., Zahlen und Gewichtsverhältnisse bei einigen heterostylen Pflanzen. *Biol. Zbl.*, 41: 97-109, '21. Reprinted in No. (1122).

Discussing heterostylism in *Fagopyrum* and *Linum*.

- (773) CORRENS, C., Versuche bei Pflanzen das Geschlechtsverhältnis zu verschieben. *Hereditas*, 2: 1-24, '21. Reprinted in No. (1122).

Recording experiments and discussing the sex ratio in *Melandrium*.

- (774) DAHLGREN, W. V. O., Vererbungsversuche mit einer buntblättrigen *Barbarea vulgaris*. *Hereditas*, 2: 88-98, '21.

Reporting double recessiveness of the variegation in *Barbarea*.

- (775) DEMEREC, M., Heritable characters of maize. X. Zebra striped leaves. *Jour. Heredity*, 12: 406-407, '21.

Giving a description of a new recessive character in maize.

- (776) EAST, E. M., A study of partial sterility in certain hybrids. *Genetics*, 6: 311-365, '21.

Hybrids between *Nicotiana rustica* and *N. paniculata* are found partially sterile. In F_2 a great range of variability was obtained.

- (777) EMERSON, R. A., Heritable characters of maize. IX. Crinkly leaf. *Jour. Heredity*, 12: 267-270, '21.

Giving a description of a new recessive character in maize.

- (778) EMERSON, R. A., The genetic relation of plant color in maize. *New York Cornell Univ. Exp. Sta. Mem.*, 39: 7-156, '21.

An extensive work on the inheritance of the anthocyanin and its distribution in maize, also giving two cases of linkage between the genes (**B-Lg** and **Pi-Y**).

- (779) EMERSON, R. A., Genetic evidence of aberrant chromosome behavior in maize endosperm. *Amer. Jour. Bot.*, 8: 411-424, '21.

Plants heterozygous for the linked genes **C** and **Wx** bear mosaic grains in which spots of colorless aleurone layer are in most cases underlaid by waxy endosperm, whereas spots of colored aleurone layer are underlaid by starchy endosperm. It is concluded that such mosaic grains are due to some aberrant chromosome behavior such as non-disjunction or elimination.

- (780) EMERSON, R. A., and C. B. HUTCHISON, The relative frequency of crossing over in microspore and in megaspore development in maize. *Genetics*, 6: 417-432, '21.

Dealing with crossing-overs in the two sexes between the genes **B** and **Lg** and between **C** and **Sh**.

- (781) EYSTER, W. H., Heritable characters of maize. VII. Male sterile. *Jour. Heredity*, 12: 138-141, '21.

Giving a description of a new recessive character.

- (782) EYSTER, W. H., The linkage relations between the factors for tunicate ear and starchy-sugary endosperm in maize. *Genetics*, 6: 209-240, '21.

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- (783) FRASER, A. C., An enumeration of the dominant characters of barley. *Sci. Agr.*, 11: 113-116, '21.

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- (784) FRIMMEL, FR., Notiz über Dominanzverhältnisse bei Fuchsienbastarden. *Zts. Ind. Abst. u. Vererbgs.*, 24: 279-281, '21.

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- (785) FROST, H. B., An apparent case of somatic segregation involving two linked factors. *Amer. Nat.*, 55: 461-464, '21.

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- (786) GARBER, R. J., A preliminary note on the inheritance of rust resistance in oats. *Jour. Amer. Soc. Agron.*, 13: 41-44, '21.

Recording crosses of two susceptible varieties with White Russian oat which is resistant to *Puccinia graminis*.

- (787) GRIFFEE, F., Comparative vigor of F_1 wheat crosses and their parents. *Jour. Agr. Res.*, 22: 56-63, '21.

Varieties of *Triticum vulgare* are crossed with each other and with one variety each, of *T. dicoccum* and *T. durum*. F₁ plants are compared with their parents with reference to weight of grain, height of culm and average yield of grain per plant.

- (788) HAGIWARA, T., On the linked genes and the linkage groups in the leaf of morning glory. (In Japanese). *Nôgaku-Kwaihō* (*Jour. Sci. Agr. Soc.*), 224: 337-377, '21. Rev. in *Jap. Jour. Bot.*, 1: (1).

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- (789) HALLQVIST, C., The inheritance of the flower colour and the seed colour in *Lupinus angustifolius*. *Hereditas*, 2: 299-363, '21.

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- (790) HAMMERLUND, C., Über die Vererbung anomaler Ähren bei *Plantago major*. *Hereditas*, 2: 113-142, '21.

Describing three abnormal spikes and their inheritance.

- (791) HASSE-BESSEL, G., Digitalisstudien II. *Zts. Ind. Abst. u. Vererbgs.*, 27: 1-26, '21.

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- (792) HAYES, H. K., and R. J. GARBER, *Breeding crop plants*. pp. 328. New York, '21.

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- (793) HAYES, H. K., and E. C. STAKEMAN, Resistance of barley to *Heminthosporium sativum*. *Phytopathology*, 11: 405-411, '21.

Recording observations on crosses between resistant and susceptible varieties of barley.

- (794) HERIBERT-NILSSON, N., Selective Verschiebung der Gametenfrequenz in einer Kreuzungspopulation von Roggen. *Hereditas*, 2: 364-369, '21.

On the inheritance of wax formation in the stem, leaves and glumes in rye.

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Giving a description of a new recessive character of maize. Also on its relationship to other genes.

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- (798) JOHNSON, J., Inheritance of disease resistance to *Thielavia basicola*. *Phytopathology*, 11: 49, '21.
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- (799) JONES, D. F., The indeterminate growth factor in tobacco and its effect upon development. *Genetics*, 6: 433-444, '21.
- (800) KAPPERT, H., Untersuchungen über den Merkmalskomplex glatt-runzlige Samenoberfläche bei der Erbse. *Zts. Ind. Abst. u. Vererbgs.*, 24: 185-310, '21.
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- (801) KATÔ, S., and Z. ISHIKAWA, The heredity of the pigments of red rice. (In Japanese). *Idengaku-Zasshi (Jap. Jour. Genetics)*, 1: 1-7, '21. Rev. in *Jap. Jour. Bot.*, 1: (5).
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- (802) KEMPTON, J. H., A brachytic variation in maize. *U. S. Dept. Agr. Bull.*, 925: 1-28, '21.
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- (803) KEMPTON, J. H., Inheritance of ramose inflorescence in maize. *U. S. Dept. Agr. Bull.*, 971: 1-20, '21.
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- (804) KEMPTON, J. H., Heritable characters of maize. VIII. White sheaths. *Jour. Heredity*, 12: 224-226, '21.
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- (805) KOTTUR, G. L., Cross-fertilization and sterility in cotton II. *Agr. Jour. India*, 16: 406-409, '21.
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(With German résumé). *Sveriges Utsä. Tidsk.*, 1921: 31-52, '21. Rev. in *Bot. Abst.*, 9: 38.

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- (807) LEHMANN, E., Über die Vererbungsweise der pentasepalen Zwischenrassen von *Veronica Tournefortii*. *Zts. Bot.*, 13: 481-530, '21.

A continuation of the author's previous observations in *Veronica*. Inheritance of the tendency to produce 5-sepaled flowers. Multiple gene hypothesis is postulated.

- (808) LEIGHTY, C., and S. BOSHNAKIAN, Genetic behavior of the spelt form in crosses between *Triticum Spelta* and *Triticum sativum*. *Jour. Agr. Res.*, 22: 335-364, '21.

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- (809) LEITCH, I., A study of the segregation of a quantitative character in a cross between a pure line of beans and a mutant from it. *Jour. Genetics*, 11: 183-204, '21.

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- (811) MALINOWSKI, E., O mieszcach kapusty z jarmuzem. *Pamiętnik Zakładu Genetycznego Szkoły Głównej Gospodarstwa Wiejskiego*, 1: 1-14, '21. Rev. in *Zts. Pfl. Zücht.*, 9: 152.

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- (812) MALINOWSKI, E., Analiza genetyczna kształtów nasion fasoli. *Pamiętnik Zakładu Genetycznego Szkoły Głównej Gospodarstwa Wiejskiego*, 1: 123-178, '21. Rev. in *Zts. Pfl. Zücht.*, 9: 153.

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- (813) MALLOCH, W.S., An F_1 species cross between *Hordeum vulgare* and *Hordeum murinum*. *Amer. Nat.*, 55: 281-286, '21.
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- (818) MIYAKE, K., and Y. IMAI, On the inheritance of flower-color in *Sisyrinchium angustifolium*. (In Japanese). *Bot. Mag., Tokyo*, 35: 261-265, '21.
- (819) MIYAZAWA, B., Studies of inheritance in the Japanese *Convolvulus*. Part II. *Jour. Genetics*, 11: 1-15, '21.
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- (820) MIYAZAWA, B., Dwarf forms in barley. *Jour. Genetics*, 11: 205-208, '21.
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- (821) MIYAZAWA, B., Vererbung bei Blattfarbe bei der Gerste. (In Japanese). *Idengaku-Zasshi (Jap. Jour. Genetics)*, 1: 9-12, '21. Rev. in *Jap. Jour. Bot.*, 1: (10).
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- (822) NAGAI, I., A genetico-physiological study on the formation of anthocyanin and brown pigments in plants. *Jour. Coll. Agr., Imp. Univ. Tokyo*, 8: 1-92, '21.

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- (823) NESS, H., Breeding work with black berries and raspberries. *Jour. Heredity*, 12: 449-455, '21.

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- (824) NILSSON-EHLE, H., Über mutmassliche partielle Heterogamie bei den Speltoidmutationen des Weizens. (Untersuchungen über Speltoidmutationen dei Weizen III.) *Hereditas*, 2: 25-76, '21.

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- (827) ORTON, C. R., and F. WEISS, The reaction of first generation hybrid potatoes to the wart disease. *Phytopathology*, 11: 306-310, '21.

- (828) OSTENFELD, C. H., Some experiments on the origin of new forms in the genus *Hieracium* sub-genus *Archieracium*. *Jour. Genetics*, 11: 117-122, '21.

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- (831) RASMUSON, H., Beiträge zu einer genetischen Analyse zweier *Godetia*-Arten und ihre Bastarde. *Hereditas*, 2: 143-289, '21.

Recording observations on varietal and species crosses in *G. Whitneyi* and *G. amoena*, with reference to the inheritance of color, size and doubling of corolla, color and shape of leaves, and habit of growth.

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- (848) TJEJBES, K., en H. N. KOOIMAN, Erfelijkheidsonderzoekingen bij boonen. IV. Over den strepingsfactor. Een geval van volkomen afstooting tusschen twee factoren. V. Analyse eener spontane kruising van de stokkievitsboon. *Genetica*, 3: 28-40, '21.

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- (860) YAMAGUCHI, Y., Études d'hérédité sur la couleur des glumes chez le riz. *Bot. Mag., Tokyo*, 35: 106-112, '21. Rev. in *Jap. Jour. Bot.*, 1: (15).

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- (863) ANDERSON, E. G., Heritable characters of maize—XI. Fine-streaked leaves. *Jour. Heredity*, 13: 91-92, '22.

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- (865) ANONYMOUS, Hybrids *Nymphaeas*. *Missouri Bot. Gard. Bull.*, 10: 127-131, '22.

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- (871) BLARINGHEM, L., Note préliminaire sur l'hérédité de la prolifération et de la duplication chez *Cardamine pratensis*. *Bull. Soc. Path. Veg. France*, 9: 138-144, '22. Rev. in *Bot. Abst.*, 12: 160.

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- (875) BLARINGHEM, L., Sur la résistance aux parasites cryptogamiques d'un hybride d'épeautre et de seigle. *Bull. Soc. Path. Veg. France*, 9: 266-276, '22. Rev. in *Bot. Abst.* 12: 525.

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Crosses between *M. oxyloba* and *M. parviflora* are made with respect to the inheritance of leaf shape. Also including remarks on some other specific crosses in *Malva*.
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- (1051) LINDSTROM, E. W., Heritable characters of maize. XIII. Endosperm defects—sweet defective and flint defective. *Jour. Heredity*, 14 : 126-135, '23.

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- (1052) LINDSTROM, E. W., Genetical research with maize. *Genetica*, 5 : 327-356, '23.

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- (1053) MAINS, E. W., and C. E. LEIGHTY, Resistance in rye to leaf rust, *Puccinia dispersa* ERIKSS. *Jour. Agr. Res.*, 25 : 243-252, '23.

Complicated genes are suggested for this character.

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- (1055) MANGELSDORF, P. C., The inheritance of defective seeds in maize. *Jour. Heredity*, 14 : 119-125. '23.

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- (1060) NAGAI, I., and S. SAITÔ, Linked factors in soy bean. *Jap. Jour. Bot.*, 1: 121-136, '23.
On the connection of seed coat color with pubescence in the soy bean.
- (1061) NOHARA S., Genetic studies on *Spinacia*. *Jap. Jour. Bot.*, 1: 111-120, '23.
On the inheritance of fruit characters (smooth vs. horned) and sex in spinach.
- (1062) OSTENFELD, C. H., Genetic studies in *Polemonium coeruleum*. *Hereditas*, 4: 17-26, '23.
Preliminary account of the inheritance in *Polemonium coeruleum*, regarding leaf-shape, corolla color, corolla length and sex.
- (1063) PARK, J. B., Inheritance of lemma appendages in cultivated barleys. (Abstract). *Anat. Rec.*, 26: 384, '23.
- (1064) PAUL, A. W., Complementary factors for depth and fasciation in tomato fruits. (Abstract). *Anat. Rec.*, 26: 385, '23.
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Concerning experiments with a variety having reduced stipules and one showing keeled alae. Also making some observations on inheritance of yellow pod and of cotyledon color. Two new linkage groups are added.
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- (1072) SAITÔ, S., The genetics of *Setaria italica*. (Japanese.) *Iden-gaku-Zasshi* (*Jap. Jour. Genetics*), 2: 67-70, '23. Rev. in *Jap. Jour. Bot.*, 2: (32).

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- (1075) SAX, K. and H. C. MCPHEE, Color factors in bean hybrids. *Jour. Heredity*, 14: 205-210, '23.

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- (1076) SCHIEMANN, E., Genetische Studien zur Sortenunterscheidung der Gerste. *Zts. Ind. Abst. u. Vererbgs.*, 30: 293-296, '23.

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- (1077) SHULL, G. H., Linkage with lethal factors in the solution of the *Oenothera* problem. *Eugenics, Genetics and the Family*, 1: 86-99, '23.

- (1078) SHULL, G. H., Further evidence of linkage with crossing over in *Oenothera*. *Genetics*, 8: 154-167, '23.

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- (1079) SINNOTT, E. W., The inheritance of fruit shape in *Cucurbita*. (Abstract). *Anat. Rec.*, 26: 386, '23.

- (1080) SIRKS, M. J., Die Verschiebung genotypischer Verhältniszahlen innerhalb Populationen laut mathematischer Berechnung und experimenteller Prüfung. *Med. Landbouwhoogeschool Wageningen*, 26: pp. 40, '23. Cited by WELLENSIEK in his paper, No. (1322).

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- (1098) WILLIAM, C. F., Hybridization of *Vitis rotundifolia*. Inheritance of anatomical stem character. *North Carolina Agr. Exp. Sta. Bull.*, 23: pp. 30, '23.

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On the inheritance of awning, color of the glume, and grain, date of heading, height of plant and resistance to stem rust and yield of plants.

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On the genic analysis of several characters in these species.

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Describing the following spontaneous hybrids *R. domesticus* × *R. crispus*, *R. domesticus* × *R. obtusifolius*, *R. crispus* × *R. obtusifolius*, *R. stenophyllus* × *R. crispus*, *R. conglomeratus* × *R. obtusifolius*, *R. pulcher* × *R. obtusifolius*, *R. dentatus* × *R. maritimus*, *R. obovatus* × *R. maritimus* and *R. obovatus* × *R. dentatus*. Hybrids are usually characterized by sterility or greatly reduced fertility.

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Recording a number of linkage tests between five virescents and other genes.

- (1127) DEMEREC, M., A case of pollen dimorphism in maize. *Amer. Jour. Bot.*, 11: 461–464, '24.

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- (1128) DEMEREC, M., Genetics of four groups of seedling characters which affect the development of chlorophyll in maize. (Abstract.) *Anat. Rec.*, 29: 133, '24.

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Including remarks on the existence of ten genes for white seedlings.

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Recording a large number of cases (about 80) of bud-mutation in the potato.

- (1131) EMERSON, R. A., Genetic evidence of aberrant chromosome behavior in maize endosperm. *Amer. Jour. Bot.*, 8: 411-424, '24.

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- (1132) EMERSON, R. A., Aberrant endosperm development as a mean of distinguishing linkage groups in maize. *Amer. Nat.*, 58: 272-277, '24.

Giving further evidence indicating that it is possible, by means of the aberrant-endosperm method, to determine the linkage relations of the several aleurone and endosperm genes of maize.

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Giving an interpretation of a significant deficiency of sugary seeds in F₂ from crosses between certain races of sugary and starchy maize.

- (1134) ENGLENDOW, F. L., Inheritance in barley. III. The awn and lateral floret (continued): fluctuation: a linkage: multiple allelomorphs. *Jour. Genetics*, 14: 49-87, '24.

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- (1135) ERNST, A., Vererbung und Bedeutung der Heterostylie. *Verhandl. Schweiz. Naturforsch. Ges.*, 105: 174-176, '24. Rev. in *Resumptio Genetica.*, 1: 268.

- (1136) EYSTER, W. H., Heritable characters of maize. Polkadot leaves. *Jour. Heredity*, 15: 397-400, '24.

Giving the description of a new recessive chlorophyll character in maize, and also its relation to other genes.

- (1137) EYSTER, W. H., Inherited deficiency in carbohydrate metabolism in maize. *Bot. Gaz.*, 78: 446-452, '24.

On the inheritance of a yellow seedling which is incapable of utilizing the carbohydrates in the endosperm.

- (1138) EYSTER, W. H., A genetic analysis of variegation. *Genetics*, 9: 370-404, '24.

Recording the experiments on inheritance of the variegated pericarp of the seed of maize based on the progeny of a single ear having dilute red or orange pericarp.

- (1139) EYSTER, W. H., A second factor for primitive sporophyte in maize. *Amer. Nat.*, **58**: 436-439, '24.

Describing primitive sporophyte and its inheritance.

- (1140) FLORELL, V. H., Studies on the inheritance of earliness in wheat. *Jour. Agr. Res.*, **29**: 333-347, '24.

Recording a cross between two varieties of spring wheat (*Triticum*) Marquis and Sunset, with a brief review of earlier literature on the inheritance of earliness.

- (1141) FRASER, A. C., Heritable characters of maize. XVIII. Intensified red and purple aleurone colour. *Jour. Heredity*, **15**: 119-123, '24.

Introducing a new gene, In, the absence of which acts as an intensifier of aleurone layer color.

- (1142) FRUWIRTH, C., Handbuch der landwirtschaftlichen Pflanzenzüchtung. Bd. II. Die Züchtung von Mais, Futterrübe und anderen Rüben, Ölpflanzen und Gräsern. 5. Aufl. Berlin, '24.

A general work on plant breeding. This volume deals with *Zea*, *Beta*, *Brassica*, *Daucus*, *Sinapis*, *Papaver* and other grasses including *Phleum*, *Poa*, etc.

- (1143) GARBER, R. J., and B. L. WADE, Another instance of defective endosperm in maize. *Jour. Heredity*, **15**: 69-71, '24.

Briefly describing a recessive defective endosperm found in a dent corn.

- (1144) GILLOT, P., Remarques sur le déterminisme du sexe chez *Mercurialis annua* L. *Compt. Rend. Acad. Sci., Paris*, **178**: 1995-1998, '24.

Further observations on sex-ratio in this plant.

- (1145) GRAHAM, R. J. D., and S. C. ROY, Linseed (*Linum usitatissimum*) hybrids. *Agr. Jour. India*, **19**: 28-31, '24.

On the inheritance of flower and seed-coat color.

- (1146) HAGIWARA, T., On the inheritance of fasciation in the Japanese morning glory. (Japanese.) *Nôgaku-Kwaishô* (*Jour. Sci. Agr. Soc.*), **355**: 54-63, '24. Rev. in *Jap. Jour. Bot.*, **2**: (46).

Suggestion is made that two genes are concerned in the production of fasciated stems.

- (1147) HAGIWARA, S., Genetic studies of leaf-characters in morning glories I. (Japanese.) *Bot. Mag., Tokyo*, **38**: 277-290, '24, Rev. in *Jap. Jour. Bot.*, **2**: (46).

Three kinds of contracted varieties are distinguished in *Pharbitis Nil*, viz. 'Uzuba-uzu', dwarf-uzu, and semi-uzu, descriptions of these forms and crosses between them being given.

- (1148) HALLQVIST, C., Chlorophyllmutanten bei Gerste. Ihre Entstehung und primären Spaltungen. *Hereditas*, 5: 49-83, '24.

Describing several chlorophyll disorders in barley: albino, xantha, lutescens, virescens, superchlorina etc.

- (1149) HAYES, H. K., and D. W., ROBERTSON, The inheritance of grain color in wheat. *Jour. Amer. Soc. Agron.*, 16: 787-790, '24.

Suggestion is made that the red color in wheat is due to di- or trimerous genes.

- (1150) HAYES, H. K., E. C. STAKMAN, F. GRIFFEE and J. J. CHRISTENSEN, Reactions of selfed lines of maize to *Ustilago zeae*. *Phytopathology*, 14: 268-279, '24.

Giving observations on F₁ of maize crosses.

- (1151) HERIBERT-NILSSON, N., Multiple monofactorielle Reduplication als der Ausdruck partialer Heterogamie bei *Oenothera fallax*. *Hereditas*, 5: 1-13, '24.

Observations on several generations of a cross, *O. Lamarckiana* (with colorless leaf-veins) ♀ × *O. biennis* (with red veins) ♂.

- (1152) HOR, K. S., Interrelations of genetic factors in barley. *Genetics*, 9: 151-180, '24.

Dealing with 10 pairs of genes and 1 triple allelomorph series, and establishing 2 linked groups with the probability of a 3rd group.

- (1153) HOWARD, G. L. C., The inheritance of characters in *Nicotiana rustica* L. *Mem. Dept. Agr. India Bot. Ser.*, 13: 17-34, '24.

Characters studied are: the time of flowering, height, relative length of stamens and pistil, form of the inflorescence, and undulations of the leaf margins.

- (1154) HOWARD, A., and G. L. C. HOWARD, Studies in Indian fibre plants. No. 3. On the inheritance of characters in *Hibiscus Sabdariffa* L. *Mem. Dept. Agr. India Bot. Ser.*, 13: 47-85, '24.

Recording crosses between four varieties of this species and identifying 18 color-genes involved.

- (1155) IKENO, S., Studien über die Vererbung der Blütenfarbe bei *Portulaca grandiflora* II. *Jap. Jour. Bot.*, 2: 45-62, '24.

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- (1156) IKENO, S., Ein Vererbungsversuche über die Grannen bei Gerste. *Jap. Jour. Bot.*, 2: 189-207, '24.

Recording results (up to F₄) of crossing between a 6-rowed entirely awned variety of barley and a less typical 6-rowed variety. Introducing several genes for development of awns.

- (1157) IKENO, S., Über einen Fall der mutativen Entstehung von letalen Faktoren im Pflanzenreich. *Biol. Zbl.*, 44: 97-106, '24.

On the inheritance of the *contorta* type in *Plantago major*.

- (1158) IKENO, S., Nachträge zu meiner Angabe über *Plantago contorta*. *Jap. Jour. Bot.*, 2: 39-43, '24.

- (1159) IMAI, Y., Genetic studies in morning glories. (Japanese.) VIII, IX, X, XI, XII, XIII, XIV. *Bot. Mag., Tokyo*, 38: 9-16, 27-44, 59-65, 103-118, 127-142, 185-220, 233-242, '24. Rev. in *Jap. Jour. Bot.*, 2: (6), (7), (48).

Describing a number of genes concerned in leaf-character and flower color, and also some cases of mutations and linkages.

- (1160) JENKINS, M. T., Heritable characters of maize. XX. Iojap-striping, a chlorophyll defect. *Jour. Heredity*, 15: 467-472, '24.

Giving the description of a new recessive type in maize.

- (1161) JONES, D. F., Selective fertilization among the gametes from the same individuals. *Proc. Nat. Acad. Sci.*, 10: 218-221, '24.

Giving an interpretation of a marked deficiency of recessives in F_2 of a cross between a pop and a sweet corn.

- (1162) KAJANUS, B., Zur Genetik der *Pisum*-Samen. *Hereditas*, 5: 14-16, '24.

Identifying genes for seed coat color in peas.

- (1163) KAJANUS, B., Über eine Kreuzung zwischen grünblättrigem und gelbblättrigem Tabak. *Hereditas*, 5: 84-86, '24.

Giving suggestion as to the genes for leaf color in tobacco.

- (1164) KAJANUS, B., Über eine eigenartige Ährenanomalie beim Weizen. *Hereditas*, 5: 217-221, '24.

On the inheritance of a peculiar spike type with an occasional adventitious spikelet.

- (1165) KAJANUS, B., and S. O. BERG, Kreuzungsstudien an Gerste. *Hereditas*, 5: 287-296, '24.

On the inheritance of 6-rowed vs. 2-rowed, hulled vs. naked grain, and grain color in barley.

- (1166) KAKIZAKI, Y., The flowering habit and natural crossing in the egg plant. (Japanese.) *Idengaku-Zasshi (Jap. Jour. Genetics)*, 3: 29-38, '24.

- (1167) KAPPERT, H., Über die Zahl der unabhängigen Merkmalsgruppen bei der Erbse. *Zts. Ind. Abst. u. Vererbgs.*, 36: 1-32, '24.

Dealing with 10 Mendelian characters in *Pisum* to determine the genetical relations between them, and identifying two cases of linkage.

- (1168) KARPECHENKO, G. D., Hybrids of ♀ *Raphanus sativus* L. × ♂ *Brassica oleracea* L. *Jour. Genetics*, 14: 375-394, '24.
The author shows that F₁ is quite uniform as to the form of pods and flowers but differs in form, pubescence, waxy efflorescence of leaves and in color of flowers, while in habit of growth and vigor it is divided into 2 or 3 types.
- (1169) KAZNOWSKI, L., Études sur la fève (*Vicia Faba*, L.) 1 Partie. Féverole de Vistule. *Pamistnik Panstwowego Instytutu Naukowego Gospodarstwa Wiejskiego w Pulawch.*: pp. 50-60, '24.
Rev. in *Resumptio Genetica*, 1: 173.
- (1170) KEARNEY, T. H., Inheritance of petal spot in Pima cotton. *Jour. Agr. Res.*, 27: 491-512, '24.
- (1171) KEARNEY, T. H., A hybrid between different species of cotton. *Jour. Heredity*, 15: 309-320, '24.
Recording crosses between the Holden variety of upland cotton and the Pima variety of Egyptian cotton.
- (1172) KELLY, J. P., Seed progeny of a potato with faintly colored tubers. *Jour. Genetics*, 14: 197-201, '24.
Describing genes for tuber-color in the cross between 'Red McCormick' whose tubers are cream with light flushes of carmine in and about the eyes and cream tubered varieties of the 'Rural' group of potato.
- 1173) KEMPTON, J. H., A dominant lethal chlorophyll mutation in maize. *Jour. Agr. Res.*, 29: 307-309, '24.
The author obtained in F₁ between 2 normal green plants, a sectorial chimera in which one-half of the plant was yellow, the other green. Crosses with normal green plants of maize and also of *Euchlaena mexicana* showed that the yellow section of the chimera is a dominant heterozygote and the derived yellow plants are lethal under field culture.
- (1174) KEMPTON, J. H., Correlation among quantitative characters in maize. *Jour. Agr. Res.*, 28: 1095-1102, '24.
Making some observations on correlation among certain quantitative characters of maize in a hybrid between the smallest and one of the largest varieties.
- (1175) KEMPTON, J. H., Inheritance of the crinkly, ramose, and brachytic characters of maize in hybrids with teosinte. *Jour. Agr. Res.*, 27: 537-596, '24.
As in hybrids with normal maize, three characters mentioned in the title are also recessive in the hybrid with teosinte.
- (1176) KEMPTON, J. H., Inheritance of proterogyny in maize. *Amer. Nat.*, 68: 182-187, '24.

- (1177) KIKUTI, A., On the origin of Japanese pears and the inheritance of the skin colors of their fruits. (Japanese.) *Idengaku-Zasshi* (Jap. Jour. Genetics), 3: 1-21, '24. Rev. in *Jap. Jour. Bot.*, 2: (50).

Suggestion is made that two pairs of genes are concerned in skin color in *Pyrus serotina* var.

- (1178) KRISTOFFERSON, K. B., Contributions to the genetics of *Brassica oleracea*. *Hereditas*, 5: 297-364, '24.

Recording crosses between various varieties of *B. oleracea*: *capitata* (cabbage), *gemmifera* (Brussels sprouts), *acephala* (kale) and *botrytis* (broccoli).

- (1179) KRISTOFFERSON, K. B., Colour inheritance in the seed coat of *Phaseolus vulgaris*. *Hereditas*, 5: 33-43, '24.

Including summary of previous results on this subject.

- (1180) KVANKAN, P., The inheritance of brown aleurone in maize. *Cornell Univ. Agr. Exp. Sta. Mem.*, 83: 1-23, '24.

Describing a new aleurone character: brown aleurone layer, and its genic analysis.

- (1181) LAIBACH, F., Frucht- und Samenbildung bei heterostylen *Linum*-Arten. *Zts. Ind. Abst. u. Vererbgs.*, 33: 267-268, '24.

On the relation of self-fertility to heterostylism in inheritance and also some observations on species crosses in *Linum*.

- (1182) LAMPE, L., and M. T. MEYERS, The mode of expression of factors influencing the carbohydrate stage in the endosperm of corn. (Abstract.) *Anat. Rec.*, 29: 131, '24.

- (1183) LATHOUWERS, V., Étude génétique de deux variations speltoïdes. *Bull. Soc. Roy. Bot. Belgique*, 57: 79-106, '24.

Recording experiments with *Triticum speltoïdes* which appeared in crosses between *T. vulgare* and *T. Spelta*, and giving comparison of his results with those of other workers.

- (1184) LEHMANN, E., Neuere Vererbungsversuche mit *Epilobien* und ihr Verhältnis zu den *Oenothera* problemen. *Zts. Ind. Abst. u. Vererbgs.*, 33: 263-265, '24.

On the appearance of a *gigas* type in F_3 of *E. montanum* $\times$ *E. parviflorum*, comparable with the *gigas* in *O. Lamarckiana*.

- (1185) LEHMANN, E., Über Sterilitätserscheinungen bei reziprok verschiedenen *Epilobium*bastarden. *Biol. Zbl.*, 44: 243-253, '24.

The author's conclusion is compared with the results of GEITH.

- (1186) LEIGHTY, C. E., and J. W. TAYLOR, 'Hairy neck' wheat segregates from wheat-rye hybrids. *Jour. Agr. Res.*, 28: 567-576, '24.

By 'neck' is meant the upper portion of the peduncle, just below the spike. 'Hairy neck' in the rye is a heritable character, contrasted with 'glabrous neck' in the wheat, but shows considerable irregularity in segregation, probably due to some aberrant chromosome behavior.

- (1187) LILIENTFELDOWNA, F. A., Bandania nad dziedzicznoscia u gwozdzka *Dianthus barbatus* L. *Ciag dalzy. Acta. Soc. Bot. Poloniae.*, 2: 15-43, '24. Rev. in *Bot. Abst.*, 14: 48.

Recording further observations on inheritance in *D. barbatus*, involving some cases of linkage, analysis of a giant form, a variety *pulverulenta* and several chlorophyll defective forms.

- (1188) LINDSTROM, E. W., A genetic linkage between size and color factors in the tomato. *Science, N. S.*, 60: 182-183, '24.

On the connection of large size of fruit with the genes for colorless epidermis of the fruit, and also some other cases of linkage.

- (1189) LINDSTROM, E. W., Complementary genes for chlorophyll development in maize and their linkage relations. *Genetics*, 9: 305-326, '24.

On the relations of three different genes for white seedlings to other genes in maize.

- (1190) LINDSTROM, E. W., and F. GERHARDT, Inheritance of carbohydrates and fat in corn. Abst. in *Iowa Acad. Sci. Proc.*, 31: 133, '24.

- (1191) LOVE, H. H., and W. T. CRAIG, The genetic relation between *Triticum dicoccum dicoccoides* and a similar morphological type produced synthetically. *Jour. Agr. Res.*, 28: 515-520, '24.

Reporting the production of a form similar to Wild Emmer from crossing Early Red Chief with Marouani, and giving genic analysis of fragility of rachis, grain and glume color.

- (1192) LOVE, H. H., and W. T. CRAIG, The inheritance of pubescent nodes in a cross between two varieties of wheat. *Jour. Agr. Res.*, 28: 841-844, '24.

Suggestion is made that probably two very closely linked genes are responsible for beardedness and pubescent nodes.

- (1193) MALINOWSKI, E., Kilka obserwacji nad mieszcancami rodzaju *Brassica*. *Pam. Zakladu. Genet. Szkoły Glówniej Gosp. Wiejskiego w Warszawie*, 2: 145-162, '24, Rev. in *Zts. Pflanzenzücht.*, 11: 179.

Recording F_1 and F_2 of several crosses: *Brassica napus oleifera annua* $\times$ *B. napus rapifera*, *B. oleracea capitata* $\times$ *B. ol. gemmifera* and *B. oleracea capitata* $\times$ *B. ol. caulorapa*.

- (1194) MALLOCH, W. S. and F. W. MALLOCH, Species crosses in *Nicotiana*, with particular reference to *N. longiflora* $\times$ *N. Tabacum*, *N. longiflora* $\times$ *N. Sanderae*, *N. Tabacum* $\times$ *N. glauca*. *Genetics*, 9: 261-291, '24.

Giving full descriptions of these hybrids, which display sterility practically or in a high degree.

- (1195) MANGELSDORF, P. C., Waxy endosperm in New England maize. *Science*, N. S., 60: 222-223, '24.

This waxy endosperm proves genetically identical with that from China.

- (1196) MEURMAN, O., Über den Einfluss des Alters auf die Vererbung einiger Samenmerkmale bei Erbsen. Kritische Nachprüfung. *Hereditas*, 5: 97-128, '24.

Giving a criticism of the experiments of ZEDERBAUER concerning the influence of the age of the plant upon the inheritance of the round-wrinkled seed and yellow-green cotyledon characters.

- (1197) MICZYNSKI, K., O dwóch nowych mieszcach pszenic. *Pamięt. Zakładu. Gen. Szkoły Główn. Gospod.*, 2: 132-137, '24. Rev. in *Zts. Pflanzenzücht.*, 10: 441.

Describing sterile hybrids between *Triticum compactum* and *T. monococcum*.

- (1198) MIYAKE, K., Y. IMAI and K. TABUCHI, On the genetic behavior of some factors in Aduki bean. (Japanese.) *Bot. Mag., Tokyo*, 38: 1-8, '24. Rev. in *Jap. Jour. Bot.*, 2: (21).

On the inheritance of stem color and seed coat pattern in Aduki beans.

- (1199) MOLDENHAWER, K., Über die Gattungskreuzungen *Raphanus* $\times$ *Brassica*. *Pamiętnik Zakładu Genetycznego Szkoły Główniej Gospodarstwa wiejskiego w Warszawie*, 2: 191-196, '24. Rev. in *Resumptio Genetica*, 2: 78.

- (1200) MYERS, C. E., Statistical studies of inheritance in the tomato. *Pennsylvania Agr. Exp. Sta. Bull.*, 189: 1-30, '24.

Studying some quantitative characters: number of fruits per plant, average weight of fruits per plant and total weight of fruits per plant in the tomato.

- (1201) NAGAI, I., Observations on the somatic segregation in soy beans. *Jap. Jour. Bot.*, 2: 63-70, '24.

Recording five cases showing a marked fluctuation in seed coat color which are considered to depend on gene mutations.

- (1202) NILSSON, E., *Urtica urens* L. var. *lanceolata* n. var. und ihr genetisches Verhältnis zu gewöhnlichen *Urtica urens*. *Bot. Notis.*, 1924: 260-268. Rev. in *Resumptio Genetica*, 1: 14.

- (1203) PRELL, H., Das Problem der Blütenfüllung bei *Matthiola annua*. *Zts. Ind. Abst. u. Vererbgs.*, 35: 286-291, '24.
Giving new interpretation of the breeding behavior of double throwing single races.
- (1204) RAMANATHAN, V., Some observations on Mendelian characters in sorghum. *Jour. Madras Agr. Students Union*, 12: 1-17, '24. Rev. in *Bot. Abst.*, 13: 877.
- (1205) ROEMER, TH., Vererbungsstudien mit Lupinen I. *Zts. Pflanzenzücht.*, 9: 271-318, '24.
Discussing somatic segregations in lupines, and also on the inheritance of seed coat pattern in connection with flower color.
- (1206) ROSÉN, D., Querques remarques sur la couleur des sépales chez l'*Anemone hepatica*. L. *Comp. Rend. Acad. Sci., Paris*, 178: 648, '24.
Giving suggestion as to the genes for flower color in *Anemone*.
- (1207) ROSENBERG, V., Unregelmässigkeiten und andere Beobachtungen bei Erbsenbastardierungen. *Zts. Pflanzenzücht.*, 10: 56-62, '24.
Concerning irregularities in a cross of Victoria pea with a variety of winter pea with reference to the hilum color.
- (1208) SAUNDERS, E. R., Further studies on inheritance in *Matthiola incana*. I. Sap color and surface character. *Jour. Genetics.*, 14: 101-114, '24.
Recording linkage between one of the two genes for sap color and one of the two genes for hoariness.
- (1209) SAX, K., The inheritance of quantitative characters. (Abstracts.) *Anat. Rec.*, 29: 136, '24.
On the inheritance of size of the ear, in connection with the color of the grain in maize.
- (1210) SAX, K., and E. F. GAINES, A genetic and cytological study of certain hybrids of wheat species. *Jour. Agr. Res.*, 28: 1017-1032, '24.
Recording crosses of varieties of *Triticum vulgare* with varieties of *T. durum*.
- (1211) SCHÜRHOFF, P. N., Die geschlechtbegrenzte Vererbung der Kleistogamie bei *Plantago* Sect. *Novorbis*. *Ber. Deut. Bot. Ges.*, 42: 311-321, '24.
The author states that the cleistogamy is linked with the female sex in this plant, the second instance of sex-linked inheritance found in plants. The behavior of cleistogamy in other plants is also discussed.

- (1212) SCHWEMMLE, J., Zur Kenntnis der reziproken Bastarde zwischen *Epilobium parviflorum* und *roseum*. *Zts. Ind. Abst. u. Vererbgs.*, 34: 145-185, '24.

- (1213) SIEGLINGER, J. B., Seed-color inheritance in certain grain sorghum crosses. *Jour. Agr. Res.*, 27: 53-64, '24.

- (1214) SIRKS, M. J., Die gynanthere Form des Goldlacks und ihre Vererbung. *Genetica*, 6: 537-548, '24.

On the inheritance of the gynanthorous form and flower color in *Cheilanthes*.

- (1215) SKALINSKA, M., Zagadnienie otrzymywania nowych odmian draga selekcji pedów w świetle doświadczeń nad rasa wielopostaciowa *Petunia violacea*. *Pam. Zakładu Gen. Szkoły Główniej Gosp. Wiejskiego*, 2: 69-121, '24. Rev. in *Zts. Pflanzenzücht.*, 11: 188.

On the inheritance of polymorphism of form and color of the flower in *Petunia violacea*.

- (1216) STEIN, E., Zur Genetik und Phylogenetik der Gattung *Salix*. *Zts. Ind. Abst. u. Vererbgs.*, 34: 249-258, '24.

Review of earlier works treating the genetics of *Salix*.

- (1217) STROMAN, G. N., Genetic relations of chlorophyll and anthocyanin seedling characters in maize. *Genetics*, 9: 91-123, '24.

Dealing with three genes for chlorophyll (W_1 , W_2 , V_1) and five genes for anthocyanin color (A , B , Pl , Y , r) and relations between them.

- (1218) STROMAN, G. N., The inheritance of certain chlorophyll characters in maize. *Genetics*, 9: 493-512, '24.

Describing three new chlorophyll disorders: yellow-white, zebra seedlings and white-base-leaf.

- (1219) SUTTON, E. P. F., Inheritance of 'bolting' in cabbage. *Jour. Heredity*, 15: 257-260, '24.

Recording the segregation as to bolting and color in a cross, green heading (non-bolting strain) ♀ × red heading (bolting strain) ♂.

- (1220) TAKAHASI, N., On the inheritance of the spring versus winter form in barley. (Japanese.) *Idengaku-Zasshi* (*Jap. Jour. Genetics*), 3: 22-28, '24. Rev. in *Jap. Jour. Bot.*, 2, (61).

The suggestion is made that the spring barley differs in a single gene from the winter barley, the former being dominant.

- (1221) THADANI, K. I., Inheritance of certain characters in *Gossypium*. *Agr. Jour. India*, 20: 37-42, '24. Rev. in *Bot. Abst.*, 15: 1032.

Giving data on the inheritance of seed fuzziness, amount of lint on seed and length of lint in American Upland, Hindi, Egyptian and Sea Island cotton.

- (1222) TRAJKOVICH, H., Inheritance of xantha seedlings in maize. *Cornell Univ. Agr. Exp. Sta. Mem.*, 82: 1-13, '24.
Describing and analyzing a new chlorophyll disorder, xantha.
- (1223) UPHOF, J. C., On Mendelian factors in radishes. *Genetics*, 9: 292-304, '24.
Dealing with genes for form and color of roots, and length of foliage, in crosses between varieties of summer radishes and between these and the black winter radishes.
- (1224) WALDRON, L. R., A study of dwarfness in wheat accompanied by unexpected ratios. *Genetics*, 9: 212-246, '24.
Recording genetical behaviors of dwarfs appeared in F₂ of a cross Marquis × Kota.
- (1225) WARREN, E., On an interspecific hybrid of *Digitalis*. *Biometrika*, 16: 205-238, '24.
A study of numerous characters in the F₁ and back-cross of *Digitalis gloxinaeflora* CLEM. by *D. lutea* L.
- (1226) WARREN, P. A., Genetic studies in *Lycopersicum*. I. The heredity of fruit shape in the garden tomato. *Michigan Acad. Sci., Papers* 4: 357-394, '24.
- (1227) WATKINS, A. E., Genetic and cytological studies in wheat. I. *Jour. Genetics*, 14: 219-171, '24.
Recording crosses between *Triticum turgidum* (with 28 chromosomes) and *T. vulgare* (with 42 chromosomes).
- (1228) WEISS, F., and C. ORTON, Further results in the inheritance of immunity to potato wart. *Phytopathology*, 14: 59, '24.
- (1229) WEISS, F., and D. ROSÉN, The supposed constancy of the hybrid between the common and the water avens, *Geum urbanum* × *rivale*. *Nature*, 114: 500, '24.
Criticizing of BLARINGHEM's previous results indicating that the hybrids between these species are constant, retaining their hybrid characters during successive generations.
- (1230) WELLINGTON, R., An experiment in breeding apples II. *New York Agr. Exp. Sta. Tech. Bull.*, 106: 1-149, '24.
Giving a detailed account of behaviors of several tree and fruit characters in selfed and crossed progenies of a number of varieties of apples.
- (1231) WENTZ, J. B., Heritable characters of maize. XVIII. Miniature germ. *Jour. Heredity*, 15: 269-271, '24.
Describing a new recessive defective seed type in maize.
- (1232) WIEBE, G. A., Albinism in barley. *Jour. Heredity*, 15: 221-222, '24.
Giving a note on the inheritance of albinism in barley.

- (1233) WOODWORTH, C. M., and L. J. COLE, Mottling of soy beans. *Jour. Heredity*, 15: 349-354 '24.

From examination, pod by pod, of a number of plants in a pure line of a mottled variety, the authors find that the mottled character is considerably influenced by environmental factors.

1925.

- (1234) AKEMINE, M., On the inheritance of dwarf-habitus in rice. (Japanese.) *Nippon Gakuzyutu Kyōkai Hōkoku (Report Jap. Assoc. Adv. Sci.)*, 1: 308-314, '25.

Dealing with three recessive dwarf types in rice.

- (1235) ANDERSON, E. G., A dominant brown pericarp color in maize. *Mich. Acad. Sci. Art. and Letters, Papers* 5: 73-75, '25. Rev. in *Exp. Sta. Rec.*, 55: 633.

- (1236) ANDERSON, E. G., Genetic factors for yellow endosperm color in maize. *Mich. Acad. Sci. Papers* 4: 51-54, '25. Rev. in *Bot. Abst.*, 15: 80.

Identifying three major genes for the production of yellow color, and studying their relations to other genes.

- (1237) BLARINGHEM, L., Observations nouvelles sur la xénie chez le blé. *Compt. Rend. Acad. Sci., Paris*, 180: 389-391, '25.

Recording F_1 results as to shape, size and weight of the hybrid endosperm produced by crossing interspecific *Triticums* and their reciprocals, such as *T. vulgare* $\times$ *T. turgidum*, *T. dicoccoides* $\times$ *T. monodurum* and *T. vulgare* $\times$ *T. monodurum*.

- (1238) BRINK, R. A., Mendelian ratios and the gametophyte generation in angiosperms. *Genetics*, 10: 359-394, '25.

Recording the inheritance of the waxy character in maize.

- (1239) CAPINPIN, J. M., A study of Mendelian inheritance in natural hybrids of rosal (*Gardenia florida* L.). *Phillipp. Agr.*, 14: 39-43, '25. Rev. in *Bot. Abst.*, 15: 540.

On the inheritance of flower color and self-sterility.

- (1240) CHRISTIANSEN-WENIGER, FR., Anatomische Untersuchungen der Blattbaues der F_2 -Generation einer Unterartkreuzung bei *Triticum* und der Versuch einer physiologischen Deutung der Befunde. *Landw. Forsch.*, 2: 81-152, '25. Rev. in *Zts. Pflanzenzücht.*, 11: 42.

Recording investigations as to the number of stomata pro quadrimillimeter in F_1 and F_2 of crosses between *T. vulgare* and *T. dicoccum*.

- (1241) CHRISTOW, M., (Inheritance studies with some tobacco varieties). *God. Sofijsk. Univ. Agron. Fakult.*, 3: 1-35, '25. Rev. in *Zts. Pflanzenzücht.*, 11: 43, *Exp. Sta. Rec.*, 54: 823.

On the inheritance of flower color, corolla form and size of corolla in *Nicotiana*.

- (1242) COLIN, H., et Y. TROUARD-RIOLLE, Le croisement orge noire à barbes lisses $\times$ orge blanche à barbes rugueuses (orge Albert). *Compt. Rend. Acad. Sci., Paris*, 180: 1129-1131, '25.

Recording further observations on inheritance of rough vs. smooth and black vs. white in the barley cross. Very complicated results are recorded up to the F_4 .

- (1243) COULTER, M. C., A distortion of the 3:1 ratio. *Bot. Gaz.*, 79: 28-44, '25.

Giving the account of investigations on a race of maize whose genic composition is Cc and which is characterized by a marked deficiency of white grains in the progeny. Interpretation is made on the assumption of a zygotic lethal gene partially linked with c.

- (1244) CRANE, M. B., Self-sterility and cross-incompatibility in plums and cherries. *Jour. Genetics*, 15: 301-322, '25.

Recording further observations on the sterility in sweet cherries, identifying 3 sterility groups in cherries and 4 groups in plums.

- (1245) DAHLGREN, K. V. O., Die reziproken Bastarde zwischen *Geranium bohemicum* L. und seiner Unterart **deprehensum* ERK ALMQ. *Hereditas*, 6: 237-256, '25.

Recording further observations on inheritance of chloroplasts in the cross shown in the title.

- (1246) DAVID, P. A., A study of inheritance in tobacco crosses involving native and imported varieties. *Phillip. Agr.*, 14: 3-35, '25. Rev. in *Exp. Sta. Rec.*, 54: 129.

On the inheritance of age of flowering, plant height and the number of leaves per plant.

- (1247) DEMEREC, M., Inheritance of pale green seedlings in maize. *Genetics*, 10: 318-344, '25.

Describing five types of pale green seedlings.

- (1248) DORSEY, M. J., and J. BUSHNELL, Plum investigations.—II. The inheritance of hardiness. *Minnesota Sta., Tech. Bull.*, 32: 3-34, '25.

- (1249) EAST, E. M., and A. J. MANGELSDORF, A new interpretation of the hereditary behavior of self-sterile plants. *Proc. Nat. Acad. Sci.*, 11: 166-171, '25. Rev. in *Bot. Abst.*, 14: 1324.

Giving accounts on self-sterility in *Nicotiana alata*, *N. forgetiana* and their hybrids.

- (1250) ENGLEADOW, F. L., and J. B. HUTCHINSON, Inheritance in wheat. II. *T. turgidum $\times$ *T. durum* crosses, with notes on the inheritance of solidness of straw. *Jour. Genetics*, 16: 19-32, '25.*

Dealing with pubescence of the glume, grain size, grain color, grain shape, endosperm texture, solidness of straw, etc., in the *turgidum-durum* cross.

- (1251) ENGLENDOW, F. L., and S. M. WADHAM, Inheritance in wheat. I. An 'unfixable wheat' (investigations on the late M. PHILLIPINE DE VILMORIN's 'race de blé nain infixable'). *Jour. Genetics*, **16**: 1-18, '25.

A closer study of genetics of the dwarf wheat of DE VILMORIN, in connection with analogous cases.

- (1252) ERNST, A., Genetische Studien über Heterostylie bei *Primula*. *Arch. d. J. Klaus-Stiftung f. Vererbungsforsch., Sozialanthropol. u. Rassenhyg.*, **1**: 13-62, '25.

Giving a new interpretation on the digenic basis as to genetical behaviors of heterostylism in *Primula*.

- (1253) EYSTER, W. H., Mosaic pericarp in maize. *Genetics*, **10**: 179-196, '25.

Recording several gradations of mosaic and the relation between them, and including discussion as to the nature of the genes.

- (1254) FRIMMEL, FR., Über die praktische Bedeutung der Bastarde erster Generation für die Tomatenzüchtung. *Zts. Pflanzenzücht.*, **10**: 453-466, '25.

Recording a large number of F₁ hybrids between various tomato varieties.

- (1255) FRUWIRTH, C., Die Genetik der Kartoffel. *Bibliogr. Genetica*, **1**: 315-359, '25.

A summary of the results of previous authors on the genetics of the potato. A chapter is devoted to hybridization between varieties. A bibliography of 181 titles is appended.

- (1256) GAINES, E. F., The inheritance of disease resistance in wheat and oats. *Phytopathology*, **15**: 342-349, '25.

Suggestion is made, from a series of crosses, that the immunity to bunt in wheats and that to covered smut in oats are due to the combined effect of a number of genes.

- (1257) GRIEFEE, F., Correlated inheritance of botanical characters in barley, and manner of reaction to *Helminthosporium sativum*. *Jour. Agr. Res.*, **30**: 915-935, '25.

Characters studied are: fertility of lateral florets, glume color, awn-texture, date of heading and reaction to the spot blotch disease. Also review of earlier works on inheritance in barley is included.

- (1258) HAGIWARA, T., Genetic studies of leaf-characters in morning glories II, III. (Japanese.) *Bot. Mag., Tokyo*, **39**: 77-97, 187-197, '25. Rev. in *Jap. Jour. Bot.*, **3**: (2).

Identifying a certain number of genes for the leaf-shape.

- (1259) HAMMERLUND, C., Zur Genetik, Biologie und Physiologie einiger Erysiphaceen. *Hereditas*, 6: 1-126, '25.

Including crossing experiments on inheritance of resistance to mildews in *Galeopsis tetrahit* and *Pisum sativum*.

- (1260) HARRINGTON, J. B., The inheritance of resistance to *Puccinia graminis* in crosses between varieties of durum wheat. *Sci. Agr.*, 5: 265-288, '25.

Production of a variety, white-grained and resistant to certain biologic forms of stem rust, from crosses between white, susceptible varieties and a red, resistant variety. Chiefly F_3 , F_4 and F_5 are recorded.

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CORRIGENDA

Page 8, line 9 from bottom, for 'flower' read 'flower.'

Page 52, lines 8 and 9, for '1) Flower: violet vs. white,

2) Stem: reddish vs. green,'

read '1) Flower: violet vs. white, } (due to the same gene pair),'
2) Stem: reddish vs. green, }

Page 56, line 15, 'SAUNDERS (201)' should be removed.

Page 76, line 19, heading, for '*Rust*' read '*Disease*.'

Page 91, line 10, for 'has' read 'have.'

Page 92, TABLE IX; page 94, line 17, for 'erectrum' read 'erectum.'

Page 116, line 14, for 'long style **Aabb**' read 'short style **Aabb**.'

Page 119, lines 12, 14 and 15, for 'aleurone' read 'embryo.'

Page 126, lines 1 and 2 from bottom; page 127, lines 4 and 5; page 128, lines 12 and 16;
page 129, line 17 and last line; page 134, line 16, for '*Langsdorffii*' read '*Langsdorffii*.'

Page 147, line 3, for 'glumes' read 'glumes.'

Page 213, line 5, after 'HOSHINO (409)' add 'KAPPERT (1167).'

Page 213, line 10, after '**R-Bt**' for '1.5' read '33.0.'

Page 264, line 2 from bottom, for '*vulgaie*' read '*vulgare*.'

Page 301, line 1 and foot-note, line 1, for 'MACGILLVRAY' read 'MACGILLIVRAY.'

Page 301, foot-note, line 5, for 'PETERSON' read 'PETERSEN.'

Page 314, last line, for '**etc**' read 'etc.'

Page 317, line 7, after EMERSON for '(778)' read '(689).'

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